AWC
Asia Water Council

Insight into Asian Water

Vol. 2 | 2024

Digital Twin
Comprehensive monitoring and pre-simulation of
water management conditions in a virtual, digital world to support decision-making

AI WTP
Intelligent water treatment plant capable of optimal operation for
using big data and AI technology

SWNM
By integrating IoT and AI advancements throughout the water supply network,
empowering proactive and dynamic responses to water leakage and water quality polution

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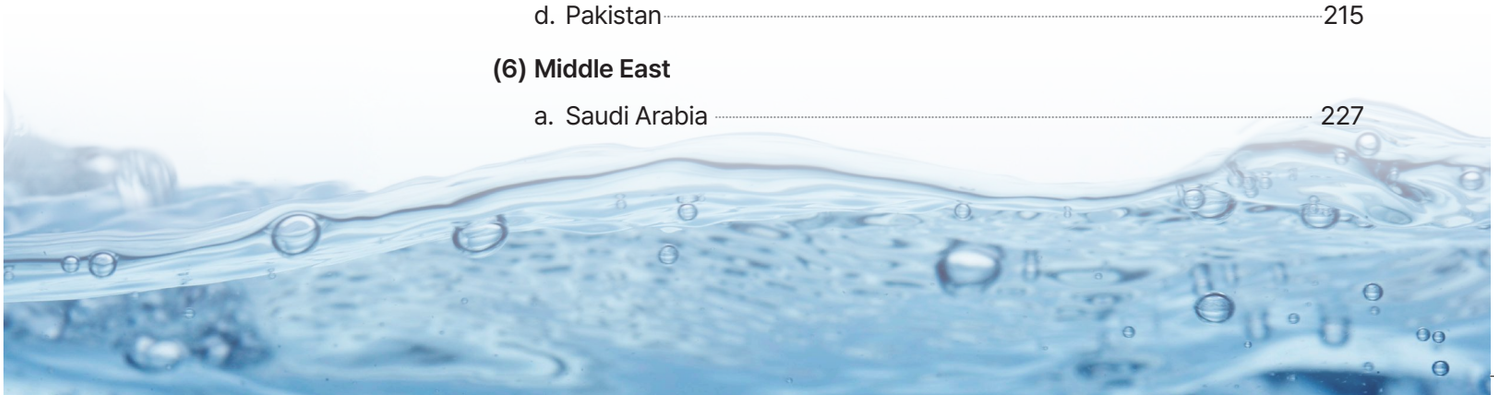


Flowing Forward: Empowering Asia's Water Future - Insights from Across the Region

Greetings, esteemed colleagues and partners,

As we stand on the threshold of the 10th World Water Forum, I am thrilled to present “Insight into Asian Water - Vol. 2 (2024)” a groundbreaking publication by the Asia Water Council (AWC). This volume is a testament to our steadfast commitment to tackling the intricate water management challenges in our region and beyond, offering unique perspectives and innovative solutions.

Contributed not only by AWC member countries and partner nations in Asia but especially by Saudi Arabia, the gracious host country of the forthcoming 11th World Water Forum in 2027, this publication represents a remarkable collaboration among diverse stakeholders united in our shared mission for water security and sustainability.

As a beacon of collaboration and innovation, the AWC has strived to elevate Asia's water issues to the forefront of global agendas, igniting sustainable development and fostering cooperation among nations. As we embark on this pivotal moment, it is our duty to harness our collective expertise and experience to drive meaningful change and pave the way for a future where clean and sufficient water is a universal right.

At the core of this publication is a comprehensive overview of water issues faced by each country, accompanied by the status of major projects and future plans of our esteemed organizations. Through meticulous research and collaboration, we have curated a wealth of knowledge and insights that serve as a valuable resource for policymakers, practitioners, and stakeholders, empowering them to make informed decisions and take effective action.

Central to our endeavor are the exemplary projects showcased within these pages, which highlight best practices from each contributor. From innovative technologies to community-driven initiatives, these projects serve as beacons of hope, demonstrating the transformative power of sustainable water management in addressing pressing challenges.

The expected outcomes of this endeavor are far-reaching. We aim to catalyze dialogue, inspire action, and forge partnerships towards achieving the Sustainable Development Goals (SDGs) by disseminating this publication to governments, national parliaments, and all water-related organizations. Through our collaborative endeavors, we will truly make a lasting impact on the lives of millions, ensuring a future where water is not just a resource but a source of life, prosperity, and resilience.

Lastly, I extend my deepest gratitude to all those who have contributed to the realization of this publication. Your dedication, expertise, and unwavering commitment have been instrumental in bringing this vision to fruition. Together, let us continue to strive towards a world where water flows freely, sustaining life and prosperity for generations to come.

Seog Dae YUN

President of the Asia Water Council

Dr. PENG Jing

President, China Institute of Water Resources and Hydropower Research (IWHR)

Water is the mother of all life, the essential resource for survival, and the wellspring of civilization. In China, water security is recognized as part of the national strategy, paramount for the long-term and sustainable development of the country. However, despite China representing nearly 20% of the global population, its share of freshwater resources is only 6%, thus posing multiple water challenges, including frequent water-related disasters, water shortages, ecological degradation and pollution of water environment.

With this in mind, President Xi Jinping put forward the innovative water governance philosophy - "prioritizing water conservation, pursuing spatially balanced development, conducting systematic governance and harnessing the synergy of government and market". Over the years, China has gained tremendous achievements and undergone historic changes in water governance, especially in flood and drought mitigation and control, water conservation, water distribution system optimization, as well as ecological protection and restoration in large river basins and lakes. Also, Asian countries and regions have their own experience in water governance acquired throughout years of practices that could be valuable to share and learn from each other.

Through the lens of Insight into Asian Water, Asian countries and regions can expand our practical cooperation by sharing water management experiences in the past and exchanging new concepts for the high-quality development of water management in the new era, and take joint actions on accelerating the process towards achieving the United Nations 2030 Agenda for Sustainable Development water-related goals. By working together on water, we can foster development, safeguard security, embrace cultural diversity, and further consolidate our wisdom and efforts in building a global community of shared future and the harmony between humanity and nature.

Mr. KONAMI Takahiro

Director, International Affairs Office, Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan

Total precipitation in Japan is estimated at around 660 billion cubic metres, but only 78.5 billion cubic metres is available for water use in Japan due to evaporation and direct run-off into the sea during floods. In this context, flood management and water resource management are closely related. I would like to introduce Japan's policy on climate change resilience in river and flood management, including planning policy and engineering achievements. Japan is willing to share its experience and knowledge with other countries through bilateral and multilateral cooperation and conferences.

Mr.Tsogtsaikhan Ganchuluun

Chairperson / Water Services regulatory Commission of Mongolia / Mongolia

As a citizen of Ulaanbaatar, I have encountered water problems in my daily life. Mongolia's urban areas often face issues such as inadequate infrastructure, mineral content in the water, and high maintenance costs of pipelines. These challenges highlight the urgent need for innovative solutions to improve water quality and availability across Mongolia.

While dealing with water problems, I tried various filters and devices to solve the issue, but nothing worked as effectively as the Vulcan Electronic Anti-Scale System. By harnessing advanced electronic technology, the Vulcan system targets the root causes of water quality degradation, such as mineral buildup, corrosion, and bacterial growth, without the need for chemicals or costly infrastructure upgrades.

Through the implementation of the Vulcan electronic water treatment system, Mongolia can significantly enhance its water quality, providing cleaner and safer water while promoting environmental sustainability. This innovative technology has the potential to positively impact the lives of Mongolia's citizens and contribute to the preservation of its natural resources for future generations.

Ms. Sarah Ransom

General Manager, Australian Water Partnership

I am pleased that Australia has had the opportunity to be included in Insight into Asian Water – vol. 2 (2024),so that our experience is shared with others in our region through this publication. Sustainable water management is more important than ever to to meeting domestic and global commitments for climate action and development, while fostering sustainable economic growth and prosperity. As an Asia-Pacific community it is vital to share knowledge and experience so that we can collectively preserve our most precious resource for the future.

Australia is the driest inhabited continent on earth. This fact has necessitated a sustained and coordinated approach to managing scarce water resources nationally and across jurisdictions. For example, after a long period of development Australian water markets are now amongst the most extensive and complex in the world. Our contribution to Asian Water provides detail about this and other innovations of interest to neighbours across the Indo-Pacific. Despite the successes to date, Australia must continue to innovate and adapt to meet the demands of a changing climate and economic growth to maintain equitable and sustainable access for all water users.

Water is a necessary part of the climate solution and without adequate attention to water management in both mitigation and adaptation, the Paris Agreement will likely be out of reach. Furthermore, water related Sustainable Development Goals are alarmingly off track. If we are to succeed in meeting these targets, working together in our region and beyond to share experiences and highlight both the challenges faced, and successes in rising to meet them, is essential. Regional and global forums, such as the Asian Water Council and World Water Forum, are crucial to supporting cooperation. As the Australian member of the AWC Board of Council, I am thrilled that Australia has been able to play a role as we work together to share and develop solutions to meet these challenges and secure water for all.

Dr. Vadim SOKOLOV

Head of Agency for Projects Implementation of the International Fund for Saving the Aral Sea, Vice-President of the International Commission on Irrigation and Drainage/ Uzbekistan

Even before the middle of XX century, people thought that natural resources were inexhaustible and that everything could be taken from Nature, and in huge quantities. But it turned out that such idea was wrong. Has anyone ever wondered how you can take so much without giving anything in return? In return, Nature, of course, received mountains of garbage, toxic emissions into the atmosphere, water and soil.

Exactly, this kind of Human behavior was the main cause of environmental tragedies - such as the Aral Sea disaster, the crisis of Salton Sea in the USA and Lake Urmia in Iran, and many other aquatic ecosystems on Earth.

Now we begin to realize our mistakes. After us, many generations will still live on this Earth. They will have to breathe clean air, drink clean water and admire the world around them.

Most environmental problems that affect humans are initially mild and appear unnoticed, but accumulate over a long period of time. Problems that appear insignificant at first glance, arising year after year, after a few years or decades lead to an environmental crisis.

Water demand is also an example of slow-onset change due to social factors such as population growth, increased use of water-intensive industrial processes, increased financial wealth, migration, and increase in the variability of extreme hydrometeorological events as the global climate changes.

Countries in different parts of the planet are struggling to solve similar water problems; as a rule, they are most concerned about overcoming the crisis on their own territory. It is important to use the World Water Forum as a social invention that helps bring together disparate groups with diverse interests to work together to address global water crises and provide the world with water resources we want.

In this section, Uzbekistan presents some of its achievements in this direction.

Dr. Ir. M. Basuki Hadimoeljono, M.Sc.

Minister/Ministry of Public Works and Housing/Indonesia

Indonesia is a country that is blessed with the potential for beautiful and abundant of natural resources, but behind its beauty lies the potential for disasters. Effective management of water resources with comprehensive mitigation measures, is expected to reduce and even prevent losses in terms of casualties, economic, social, cultural, as well as facilities and infrastructures. Utilization of water resources requires optimal management so that water security can be realized hence drought in the dry season and flooding in the rainy season will not continue to occur.

Water resources infrastructure development, especially the construction of dams is a strategic policy option that can overcome these problems. Efforts to increase the ratio of water storage to population to reach 120 m^3 per capita per year continue to be carried out in accordance with the Ministry of Public Work and Housing's Vision 2030. The construction of 61 completed and on-going dams and 11 new dams is a strategic program whose target achievements are measurable. Sustainable management, operation and maintenance of dams needs to be done so that they can be useful for the long term.

This publication contains best practices on water-related issues and solutions in Indonesia. It is hoped that it can inspire and raise awareness regarding the handling and management of water resources as well as support the implementation of the duties and functions of the Ministry of Public Works and Housing in the context of developing reliable water resources infrastructure. Water resources infrastructure of various kinds has been, is being, and will continue to be built throughout Indonesia.

I believe Insight into Asian Water will provide the most current information dealing with sustainable water resources management. Insight into Asian Water will inspire and offer us both perspective and punditry. It makes the subject of water, water resources, and water's interactions in the environment understandable, approachable, and relevant to a wide range. I convey my appreciation and thanks to all parties who supported the process of compiling this book as a contribution to the progress of sustainable water resources management.

Finally, I hope the account of some experiences which are shared across, will help others facing similar challenges. Perhaps from the story of some countries, and from the guidelines they commit with, some other countries may find clues that will help them to learn and to deal with the similar issues.

Engr. Leonor C. Cleofas, CESO IV

Administrator, Metropolitan Waterworks and Sewerage System – Corporate Office, Philippines

This comprehensive publication," Insight into Asian Water: Focus on Water Projects in Asian Countries," with a special emphasis on the Philippines, is a reflection of a collaborative efforts and strategic partnerships between the Metropolitan Waterworks and Sewerage System (MWSS) and our concessionaires, Manila Water Company, Inc., Maynilad Water Services, Inc., and Luzon Clean Water Development Corporation. It showcases our shared commitment to achieve and strengthen the water security, sustainability, and resilience, both locally and across our service areas.

Tracing back to the 1900's the water sector in the Philippines faced significant challenges, including inadequate water supply coverage and high rates of non-revenue water. The decision to privatize MWSS in 1997 marked a significant shift, leading to substantial improvements in the management of water supply and sewerage systems. Through detailed case studies, this contents of this section of the publication sheds light on our journey from addressing urgent water needs to adopting innovative solutions that markedly improved the water infrastructure in the Philippines.

The featured projects, such as the Umiray-Angat Transbasin Rehabilitation Project, Angat Water Transmission Improvement Project (AWTIP), Novaliches-Balara Aqueduct 4, Parañaque 'New Water' Treatment Plant, and the Bulacan Bulk Water Supply Project, highlight our ongoing commitment to sustainable water management and technological innovation. These projects demonstrate our proactive approach in tackling water scarcity, enhancing water quality, and building resilient infrastructure to support the people we serve.

As the oldest water system in Asia, MWSS has grown into a key player in promoting sustainable water resource management. Our work with our concessionaires demonstrates how public-private partnership can overcome challenges and achieve common goals, enhancing our service delivery and capacity for action.

Looking ahead, MWSS is dedicated to laying the foundation and building its Water Security Pillars, guiding our strategies for ensuring the availability and sustainability of water resources for the future. Through re-engineering of existing water infrastructures, water source augmentation, and long-term water security projects, we are committed to building a resilient water future for the Philippines and setting examples of effective water management practices for Asia.

This documents not only our past and present achievements, but also articulates our shared vision for a sustainable water future. It underlines our continuous commitment to innovation, resilience, and sustainability in water, sewerage, and sanitation management, aiming to inspire other efforts worldwide. Sharing our experiences, challenges, and solutions, we aim to contribute to the stream of knowledge on water security, highlighting the essential role of public-private partnerships in sustainable development.

Dr. Surasri Kidtimonton

Secretary-General, Office of the National Water Resources, Thailand

Water is the essence of life and fundamental to the survival of communities, economies, and ecosystems. The challenges posed by rapid urbanization, industrialization, and climate change highlight the crucial need for sustainable water management. In Asia, the stress on water resources is becoming increasingly severe.

In response to these issues, the Office of the National Water Resources, Thailand, would like to presents "Insight into Asian Water," in which experts, policymakers, and practitioners have contributed to this comprehensive exploration of water-related challenges and solutions in Asia, including Thailand, to illuminate the wide range of water management issues in Asia.

Thailand has implemented a robust master plan for water resources management, leveraging advanced technology and innovative strategies to effectively respond to changing environmental conditions, especially in light of climate change. By utilizing predictive capabilities and implementing proactive surveillance, our primary goal is to address water-related challenges to accelerate positive change towards more sustainable water management practices.

We extend our heartfelt appreciation to all contributors and partners who have generously shared their insights and experiences for this publication. It is our sincere belief that "Insight into Asian Water" will serve as a valuable resource for policymakers, researchers, and practitioners as we collectively work towards the shared goal of ensuring water security and resilience throughout Asia.

Mizanur Rahman Ph.D.

Deputy Managing Director, Dhaka Water Supply and Sewerage Authority

The vision of Dhaka Water Supply and Sewerage Authority (DWASA) is to be the best water utility in the public sector of Asia by ensuring environment friendly, sustainable and pro people water management system. To ensure sustainable water supply management system, DWASA developed the Water Supply Master Plan for Dhaka City in 2014. Following the master plan, DWASA has taken initiatives to establish District Metered Area (DMA) in Dhaka city through different projects. Under these projects already 104 DMAs have been established. In the DMA area, pressurized water supply can be maintained for 24/7, all illegal house connections are legalized at the initial stage of DMA establishment. Water supply is provided in Low Income Community (LIC)/slum area in a systematic manner. Easy operation & maintenance can be ensured in the DMA area. Average Non-Revenue Water (NRW) has been reduced up to less than 5% in DMA area.

Mr. Anshuman

Director, Water Resources Division, The Energy and Resources Institute (TERI), New Delhi, India.

As the world traverses through the ever-evolving and glaring challenges of climate change, coping with the ever-increasing water stress and scarcity across various regions of the world has become even more arduous task requiring futuristic planning and collaborative action.

India's economic growth and development has set the water demand ever-increasing in different sectors while the per capita water availability has seen a consistent decline over the past many decades. The already challenging state of inefficient water use, overexploitation & pollution of water bodies is further aggravated by the impacts of climate change, leading to an undeniable stress on the available water resources.

With the Sustainable Development Goals (SDG-6) set targets of 2030 in sight, it is rather an urgent requirement to adopt water efficient technologies and best practices, promote water conservation, wastewater recycle/reuse & resources recovery, and move towards a circular economy. This is also vital for climate resilient pathways towards a net zero future ambition.

Government of India has initiated several key policies and programs in response to its water challenges that has started to show positive impacts. Some of the recent flagship programs such as 'Namami Gange' (river cleaning and conservation), 'Swatch Bharat' (Sanitation related), 'Jal Shakti Abhiyan' (focus on water conservation), 'Jal Jeevan Mission' (potable water to all), 'Atal Bujal Yojna', Prime Minister Krishi Sinchayi Yojna' (irrigation water use efficiency), 'Atal Mission for Rejuvenation and Urban Transformation (AMRUT)' etc. are remarkable initiatives in this regard.

It's a proud milestone for us at The Energy and Resources Institute (TERI) to have completed 50 years of our existence in promoting policy reforms, sustainable solutions and best practices in the field of water, environment and sustainable development through multi-stakeholder engagements and collaborative partnerships.

It is heartening for us to be part of Asia Water Council's initiatives on the global water cooperation to promote global solidarity of Asia in addressing the water issues in the region. I express my hearty compliments and sincere appreciation for the Asia Water Council and all the stakeholders involved in this initiative. We strongly believe the future shall be much more secure and sustainable with collaborative action, inclusive growth and sustainable lifestyles.

Er. Ramdeep Sah

Chairman,
Smart WASH Solutions,
Nepal

Er. Pradip Kumar Mudavari

Director,
Smart WASH Solutions,
Nepal

Smart WASH Solutions was established in 2018 as a non-profit organization. It aims to raise awareness of WASH problems in Nepal. It will strengthen cooperation among stakeholders on finding solution to WASH problems by sharing knowledge experience, building capacities as well as implementing new technologies. Smart WASH Solutions works to contribute in solving WASH problem though Policy Advocacy, Research, Innovation, Capacity Building, implementing New Technologies and dissemination of Information.

We would like to express our sincere appreciation to Asia Water Council (AWC) for selecting us and giving an opportunity to write water related issues and solutions of Nepal for the Publication of the "Insight into Asia Water-vol. 2 (2024)" for upcoming 10th World Water Forum that will take place in May 2024 in Bali, Indonesia.

We would like to express our sincere thanks to following experts for their contribution by providing information's in writing this publication.

- Mr. Dr. Kapil Gnawali, Senior Divisional Hydrologist/Engineer, Water and Energy Commission Secretariat (WECS)
- Mr. Ajay Raj Adhikari, Project Director, Mechanized Irrigation Innovation Project (MIIP), Department of Water Resources and Irrigation (DWRI)
- Mr. Madhav Prasad Koirala, Former Deputy Managing Director, Nepal Electricity Authority (NEA)
- Mr. Kabindra Pudasaini, Sanitation Expert, Water Aid, Nepal
- Mr. Kailash Sharma, Head of Partnership (Governance, WASH & Energy), Diyalo Technologies, Pvt. Ltd.

We express our gratitude to Er. Hari Prasad Sharma, CEO of Smart WASH Solutions, for his invaluable input in writing this report, as well as to Ms. Melina Khanal, Secretariat, Smart WASH Solutions for her invaluable support in its preparation.

We have tried to cover all sectors of water of Nepal. Report includes energy sector, irrigation sector and water supply and sanitation sector. We have presented current scenario of water sector of Nepal and elaborated water related issues and solutions of ongoing and completed projects and impact of climate change in the projects have been accessed in detail. Finally, we have suggested and recommended future plan with plan of action to overcome impact of climate change and deteriorated environment in the water sector projects of Nepal. We hope global community could get information about issues and challenges in the water sector projects of Nepal after its publication in upcoming 10th World Water Forum.

Mr. Brig. Muhammad Aslam Khan (Retd)

Chairman Gomal Damaan Area Water, Partnership, Pakistan and Member of Asia Water Council

Water is the lifeblood of nations, sustaining ecosystems, economies, and livelihoods. Nowhere is this more evident than in Pakistan, where water plays a central role in agriculture, industry, and daily life. However, Pakistan is facing a formidable water crisis, compounded by factors such as scarcity, contamination, mismanagement, and the looming spectre of climate change. As we delve into the complexities of Pakistan's water landscape, it becomes increasingly clear that understanding the sources of these challenges and charting a path towards sustainable solutions is imperative for the nation's future.

In the summer of 2024, Pakistan braces for what experts predict to be one of the most severe water crises yet, exacerbated by the effects of global warming and the melting of glaciers in the northern regions. Against this backdrop of impending crisis, it becomes essential to examine the multifaceted dimensions of Pakistan's water woes from various perspectives.

This preface serves as an entry point into a comprehensive exploration of Pakistan's water crisis, delineating its causes, ramifications, and potential remedies. Although there are over 20 mega projects completed in recent past and similarly, 20 projects in various stages of planning and completion. However, the discussion of the article will mainly focus on five on-going and five completed projects of Pakistan which are and will be contributing in reducing water crisis of Pakistan. We approach this examination from three critical angles:

Water Management Mechanism: Central to addressing Pakistan's water crisis is a robust and efficient water management mechanism. We delve into the intricacies of water governance, exploring the roles of federal and provincial authorities, the challenges of inter-provincial water disputes, and the imperative of fostering collaboration for sustainable water management.

Infrastructure Development: Pakistan's water infrastructure plays a pivotal role in mitigating the effects of the water crisis. We examine completed and on-going projects, such as dams, hydropower initiatives, and irrigation schemes, assessing their impact on water security, energy generation, and socio-economic development.

Policy and Regulation: Effective policies and regulations are indispensable for addressing Pakistan's water challenges. We analyse existing policies, propose reforms, and advocate for measures such as water conservation, public awareness campaigns, and international cooperation to ensure equitable water distribution and sustainable water use.

Through meticulous research, expert analysis, and insights gleaned from stakeholders across sectors, we aim to shed light on the complexities of Pakistan's water crisis and illuminate the path forward. Our exploration is guided by a commitment to fostering dialogue, catalysing action, and galvanizing stakeholders towards collective solutions that safeguard Pakistan's water resources for present and future generations.

As we embark on this journey, we invite readers to join us in confronting one of Pakistan's most pressing challenges with resolve, ingenuity, and a shared vision of a water-secure future for all.

Dr. Abdulaziz M. Alshaibani

Deputy Minister for Water Organization, Ministry of Environment Water & Agriculture

Saudi Arabia is a land of striking contrasts—a vast expanse of deserts and mountains punctuated by oases, a place where tradition meets modernity and a nation that balances rapid development with preserving its natural heritage. Saudi Arabia has one of the world's most arid climates. Despite these challenges, the Kingdom has made remarkable strides in addressing water scarcity through innovative approaches. Yet, as population and economic growth continue to increase, the demand for water rises, necessitating more sustainable practices.

We delve into the impact of climate change, rapid urbanization, and agricultural practices on water resources. By carefully analyzing these factors, we aim to shed light on the complexities of water management in a region deeply reliant on this essential resource. Moreover, we present successful case studies and initiatives from Saudi Arabia, highlighting the potential for achieving water sustainability. These examples inspire and provide practical strategies for optimizing water use, promoting conservation, and enhancing water quality.

Water availability and sustainability challenges in Saudi Arabia are not just technical or environmental but also social and cultural. As you read this article on water issues and projects, you will understand how the Kingdom is working to balance the needs of its people, industries, and ecosystems while safeguarding its water resources for the future. We thank the AWC for providing Saudi Arabia a platform to exhibit its projects and emphasizing the significance of sharing exemplary approaches.

The Kingdom of Saudi Arabia is aware of worldwide water problems. We can work together to ensure a resilient and thriving future for the Kingdom and its people by fostering greater awareness of water sustainability issues and solutions. Saudi Arabia will be the host of the World Water Forum 11, providing a valuable platform for sharing of knowledge and the promotion of sustainable development.

Prof. Shie-Yui Liong

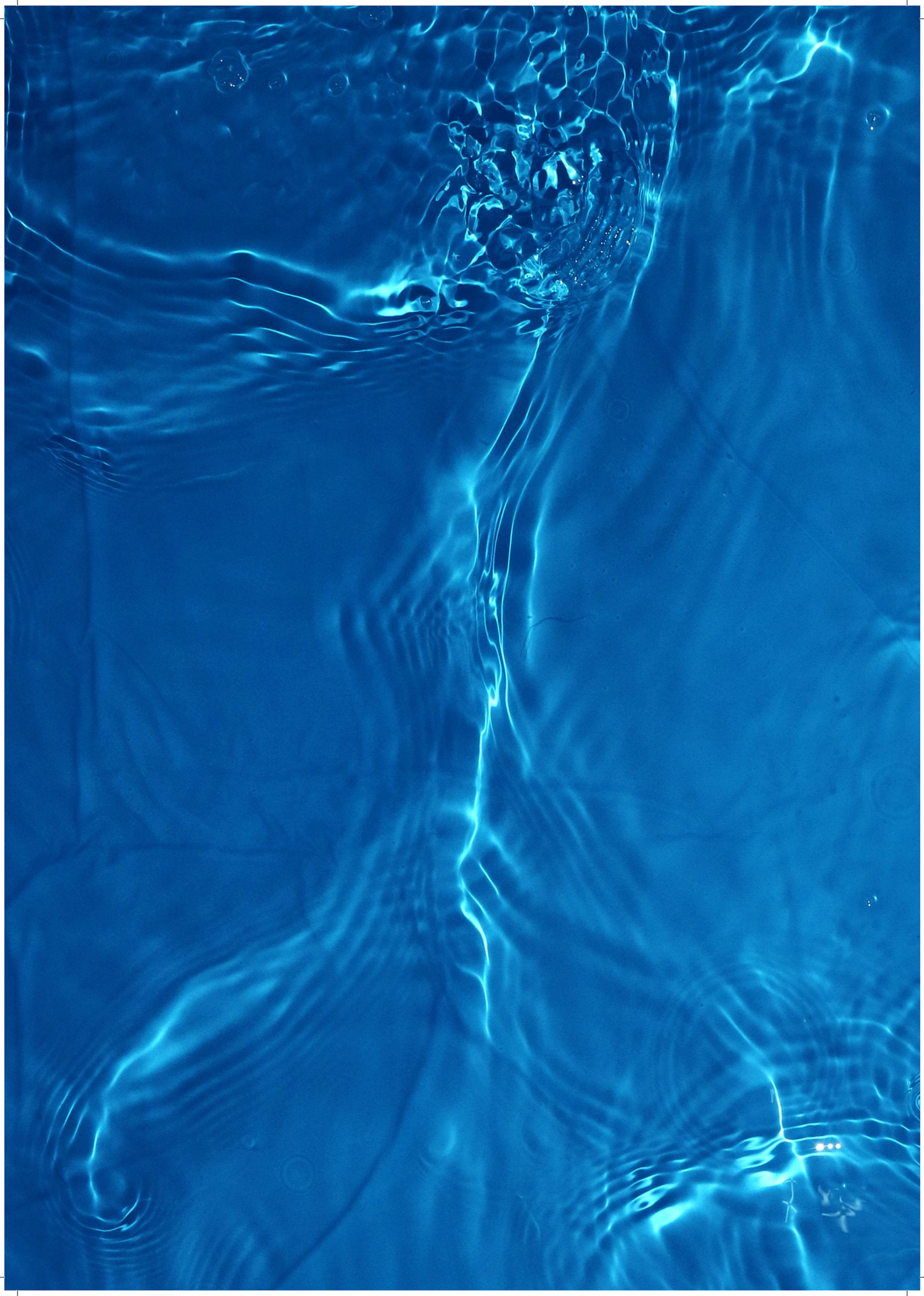
Honorary Member & Former Treasurer of Asia Water Council (AWC)

We are absolutely delighted to receive enthusiastic responses from many countries when we solicited articles to highlight their exciting water activities for inclusion in Volume II of "Insight into Asian Water". We firmly believe that we all are able to learn the challenges our colleagues faced and how they solved those issues. Our publication team tried our level best to streamline this volume, such as specific subsection topics, number of pages etc. Unfortunately, some didn't follow the request. In lieu of time restrictions and particularly their very interesting subjects we included their submissions in entirety in the report. We thank you for your contributions. We personally enjoyed the submitted reports and hope you do too. Happy reading!

Dr. Nidal SALIM

Director General of GIWEH - Global Institute for Water Environment and Health
Treasurer of Asia Water Council (AWC)

We extend our heartfelt gratitude to our contributors from various countries for their enthusiastic responses to our call for articles. These articles, which showcase exciting water-related activities across Asia, form the core of this second volume. Our aim is to share the diverse challenges our colleagues have encountered and the innovative solutions they have crafted in the realm of water management. Asia's relationship with water is ancient and complex, shaped by its varied climates, rich cultures, and historical intricacies. In this volume, we delve into a succinct overview that includes the historical context of water management, significant water projects in various countries, and contemporary solutions addressing current challenges: Smart Water Management: Several Asian countries are at the forefront of adopting smart technologies for water conservation and management. These include the use of sensors, data analytics, and IoT technologies to optimize water usage. Wastewater Treatment and Desalination Projects: As freshwater scarcity intensifies, countries with extensive coastlines are increasingly turning to desalination technologies. Community-based Water Management: These initiatives foster community involvement in local water resource management, enhancing the sustainability of irrigation and drinking water supplies. International Cooperation: The transboundary nature of many of Asia's water resources necessitates robust international cooperation. Our editorial team has worked diligently to streamline this volume, organizing content into specific subsections and maintaining consistency in pagination. However, some contributions, due to their exceptional content and the constraints of time, have been included in their entirety. We are truly grateful for all the submissions received and have found great enjoyment and insight in these reports. We hope you will find the reading equally rewarding.



Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

East and North East Asia

China

China Institute of Water Resources and Hydropower Research (IWHR)

1. Introduction

(1) Water resources in China

Situated in the southeastern part of the Eurasian continent and on the west coast of the Pacific Ocean, China enjoys a distinct monsoon climate. Due to the unique geographic and climatic conditions, the distribution of water resources in China is unbalanced both spatially and temporally. It is characterized by high flow in summer and low flow in winter, with scarcity in the north and abundance in the south. China is among the countries facing the most complex water systems, the most challenging watershed conditions, and the most difficult tasks of water governance. For example, the average annual precipitation in the southeastern coastal areas is more than 2,000 mm, while it is less than 200 mm in the northwestern areas, particularly below 50 mm in the Tarim Basin. The northern areas account for only 18% of the national water resources, which is significantly lower compared to the percentages of land area (64%), arable land (64%), population (46%), and gross domestic product (GDP, 39%). 60–80% of the annual precipitation is concentrated during the flood season, leading to alternating occurrences of high or low water flows.

Per capita water resources in China stand at about 2,000 m^3, which is only 35% of the world average. Meanwhile, three-fourths of the land area in China is prone to floods. With continuous economic and social development, a variety of water challenges have emerged as significant factors hindering China's development. These challenges include the shortage of water resources, damage to water ecosystems, pollution of the water environment, and frequent water-related disasters.

Under the context of global warming, extreme hydrological events such as droughts and heavy rainfalls tend to occur more frequently and concurrently in China, intensifying risks to the society when coupled with socio-economic systems. In 2021, for example, the maximum hourly precipitation during the July 20 Zhengzhou rainstorm reached 201.9mm, breaking the record in mainland China. Historically rare autumn floods hit the middle and lower reaches of the Yellow River, while rainfall remained below normal in the Pearl River Basin, resulting in the most severe drought in some areas in 60 years. In 2023, the Haihe River basin was stricken by the largest basin-scale flood since 1963, 8 rivers experienced the worst flooding since documented data appeared.

(2) Water governance practices in China

Water governance has always been a top priority for the Chinese government. Since1949, the country has initiated numerous major water conservancy projects, including the Three Gorges Project on the Yangtze River, the Xiaolangdi Project on the Yellow River, and the South-to-North Water Diversion Project. As a result, water resources allocation has thus been continuously optimized, and the security of urban and rural water supply has been significantly enhanced. At the same time, China has implemented a series of institutional innovations in the conservation, protection and management of water resources. The Water Law of the People's Republic of China was adopted in 1988, and the most stringent water resources management system ever was introduced in 2012. The Chinese government attaches great importance to national water security. In 2014, President Xi Jinping introduced China's top water governance philosophy, emphasizing "prioritizing water conservation, pursuing spatially balanced development, conducting systematic governance, and harnessing the synergy of government and market". This philosophy underscores the importance of coordinated actions in preventing water-related

disasters, conserving water resources, protecting and restoring water ecosystems, and enhancing the water environment. These innovative approaches to water governance now serve as the fundamental guidelines for safeguarding China's water security.

China has built the world's largest and most extensive water conservancy infrastructure systems, benefiting the largest number of people. By 2022, there were 95,300 reservoirs with a combined storage capacity of 988.7 billion m^3, and the water supply capacity of national water conservancy works exceeded 900 billion m^3. China's overall flood and drought prevention capability has been enhanced. In the recent decade (2014–2023), the average annual number of deaths and missing persons due to flooding decreased from 1,481 to 445. Additionally, the average annual loss due to flooding as a percentage of GDP dropped from 0.51% to 0.24%, compared with the previous decade (2003–2012). In 2019, the National Development and Reform Commission (NDRC) and the Ministry of Water Resources (MWR) jointly released the National Action Plan for Water Conservation, elevating water conservation to a national priority and prompting nationwide action. In 2024, the Regulations on Water Conservation were unveiled and came into force to comprehensively and systematically regulate and promote water conservation activities. It provides a strong legal guarantee for safeguarding national water security, advancing ecological civilization, and promoting high-quality development. Over the past ten years, water use efficiency and effectiveness have substantially improved, while the annual water consumption has remained stable at around 610 billion m^3. Water pollution and degradation of water ecosystems have been effectively reversed.

The national water network initiative represents another achievement of China's water governance in the new era. China's national water network is a comprehensive system with natural rivers and lakes as the foundation, diversion and drainage works as channels, and storage and regulatory reservoirs as nodes. By intelligent regulation, it facilitates optimal water resources allocation, river basin flood prevention, disaster mitigation, and protection of aquatic ecosystems. It is imperative to accelerate the development of the national water network so that a spatial balance of water resources can be achieved on a broader scale, and super-large water conservancy projects can then fully demonstrate their advantages and comprehensive benefits. This initiative will safeguard national water security at a higher level to support the development of a modern country in all aspects.

2. Selected Completed Projects

(1) The South-to-North Water Diversion Project

a. Background

The South-to-North Water Diversion Project is a key strategic infrastructure specifically designed to alleviate the severe water shortage in northern China. The project has delivered significant economic and social benefits since it was deployed. The project encompasses eastern, central, and western routes. The first phase of the eastern and central routes was completed and became operational in 2013 and 2014, respectively. They have altogether diverted 70 billion m^3 of water to over 280 cities and counties, including Beijing and Tianjin, and have become the primary source of water for more than 140 million people. In addition, the project facilitates

ecological water replenishment of 21 rivers and lakes along the routes, thereby reducing groundwater over-exploitation in the water-receiving areas.

b. Challenges

The South-to-North Water Diversion Project faces the following scheduling and operational challenges:

1) It is challenging to ensure coordinated operation of the water diversion system and to achieve optimal synergy among different objectives along a canal of thousands of kilometers facilitated with multiple reservoirs, sluice gates, and other water infrastructures;
2) Extreme climate events caused by global warming are having increasingly significant impacts on the safe operation of the project;
3) It is necessary to strengthen maintenance and upgrade some equipment and facilities, signs of aging with the continued operation of the project;
4) It is difficult to promote win-win cooperation among multiple stakeholders and parties with different interests and concerns.

c. Solutions

The South-to-North Water Diversion Project has been in operation for ten years, functioning steadily without any significant incidents. On May 14, 2021, President Xi Jinping highlighted the valuable experiences drawn from the implementation of inter-basin water diversion projects when presiding over a symposium on advancing the high-quality follow-up development of the South-to-North Water Diversion Project.

- Applying a holistic perspective involves subordinating partial interests to overall interests and the local governments submitting to the central government. This coordination ensures nationwide resources are optimally allocated at the central level.
- Pooling all resources to complete major tasks. Guidance should be provided at the central level to secure resources for project implementation, including funding and land resources, and to resettle residents in a coordinated and appropriate manner.
- Respecting the physical laws. It is important to discuss the project proposal in a scientific and practical manner, with attention paid to environmental protection. We strive to achieve harmony between water and humans.
- Developing comprehensive planning to coordinate water resources and systems in the basins of the Yangtze River, Huaihe River, Yellow River, and Haihe River, considering the requirements of all pertinent regions and industries.
- Emphasizing water conservation and pollution control. Water diversion should be implemented based on water conservation, water access should be based on pollution control, and water use should be based on environmental protection.
- Diverting water in a precise manner. A detailed water allocation plan should be developed to enhance the accurate delivery of water from sources to users.

In summary, a variety of effective measures have been implemented in terms of institutional mechanisms, water flow regulation, and ecological protection to ensure the long-term stable operation and sustainable development of the South-to-North Water Diversion Project. These measures have made significant contributions to China's water resources allocation and environmental protection.

(2) River basin ecological restoration and ecological water replenishment - An example from the Yongding River

a. Background

The Yongding River is one of the most important rivers in the Haihe River Basin. Being called Beijing's "mother river", this waterway serves as a natural corridor that runs through the Beijing-Tianjin-Hebei ecological functional area and plays a crucial role as a water conservation area and ecological barrier in the Beijing-Tianjin-Hebei region. Due to the extensive exploitation and utilization of the water resources, the lower Yongding River was dried up for years, significantly undermining the river corridor and its ecological functions. For this reason, priority was given to the Yongding River in the ecological restoration of the Haihe River Basin. According to the Overall Plan for Comprehensive Management and Ecological Restoration of the Yongding River, the goal is to restore the river to a "dynamic, green, clean and safe river", rejuvenating the natural landscape with flowing rivers, shimmering lakes, lush greeneries, and an integrated urban-rural environment.

b. Challenges

1) The systematic restoration of the natural flow of the Yongding River requires key technologies for reconstructing the green ecological corridor of sand-laden dried-up rivers;
2) Water resources for ecological water replenishment, which are limited, should be allocated and secured in a more scientific and appropriate manner. It is important to accurately allocate and scientifically regulate water flow at basin scale so that different water sources can be used in a scientific and appropriate manner for ecological water replenishment;
3) It is necessary to scientifically maintain the water quality and aquatic ecosystem stability of urban artificial landscape water bodies (ALWs) replenished with reclaimed water.

c. Solutions

1) Innovative ecological corridor restoration strategies for sand-laden dried-up rivers have been proposed: artificial guidance, natural development, and natural succession. These strategies fill the gap in the technical theory of natural restoration and elastic regeneration of green river corridor landscapes in northern sand-laden dried-up rivers. They have been integrated into the Yongding River comprehensive management plan, contributing to the major modifications of the ecological restoration plan for the dried-up sections of the Yongding River.
2) Technologies proposed include the "four-division + coordination" technique for determining ecological flow, assessing water quality risks of diverse water sources, purifying water in wetlands, optimizing the allocation of river basin water resources from various origins to ensure ecological flow (including local runoff, reclaimed water, and water from the Yellow River and Yangtze River), and implementing multi-reservoir joint scheduling for ecological water replenishment. These technologies solve the problems of precise allocation and optimal regulation of water resources at the basin scale, providing strong support for ecological water replenishment of the Yongding River.
3) To meet the technological demand for "improving water quality", ecological function enhancement technologies and schemes have been proposed for large-scale stagnant ALWs. These technologies aim to enhance the ecological functions of stagnant ALWs in the Yongding River.

(3) Pishihang Digital Twin Irrigation Area Project in Anhui Province

a. Background

With a designed irrigation area of 732,000 hectares (10.98 million mu), the Pishihang Irrigation Area in Anhui Province is one of the three mega irrigation areas in China that exceed 666,667 hectares (10 million mu). The Pishihang Digital Twin Irrigation Area Project promotes the digital development, automated monitoring, and intelligent regulation of irrigation area. The project aims to enhance the management, allocation, conservation, and intensive utilization of water resources through digitalized scenarios, intelligent simulations and precise decision-making.

b. Challenges

1) The complex irrigation and drainage system comprises 6 large reservoirs, 3 head canals, 7 levels of fixed channels with a total length of 25,000 km, over 60,000 canal structures, 1,200 small and medium-sized reservoirs, 200,000 weirs, and 4 replenishment lakes;
2) Water supply serves diverse purposes, including irrigation, ecological water replenishment of rivers, and domestic water supply for 11.3 million residents;
3) Deep integration of extensive multi-source data, multiple water-related models, and complex application requirements.

c. Solutions

1) Monitoring, sensing and automatic control facilities have been established to provide data support for water resources management, flood control and drought relief.
2) Communication and transmission networks, GIS platforms and cloud computing platforms have been established to facilitate the unified management of water resources in irrigation area.
3) Four intelligent models have been developed to support intelligent management decision-making on water supply and use in the irrigation areas. These models include water supply and demand prediction, water resources allocation, water supply regulation, and channel flood control scheduling.
4) Eight application modules have been developed, including water resources allocation and regulation, channel flood control scheduling, and water supply and use management, to achieve digital empowerment for the safe and efficient operation and management of the irrigation area.

(4) Datengxia Water Conservancy Hub Project

a. Background

The Datengxia Water Conservancy Hub Project is located in Guiping City, Guangxi Autonomous Region. It sits at the exit of the Dateng Gorge in the Qianjiang River section in the Pearl River Basin. With a total reservoir capacity of 3.479 billion m^3 and a flood control reservoir capacity of 1.5 billion m^3, the Datingxia Water Conservancy Hub is a pivotal regulating facility in the Pearl River Basin for flood control, navigation, power generation, water resources allocation, and irrigation. The main structure of this project was completed in September 2023.

The urban agglomeration located at the mouth of the Pearl River Delta has long been affected by salty tides due to the uneven spatial and temporal distribution of water resources and its geographic location. The Datengxia Water Conservancy Hub controls 56% of the water resources of the Xijiang River which is a tributary of the Pearl

River. The facility opens up the key node of the Pearl River Golden Waterway, allowing vessels of up to 3,000 tons can now navigate in the Qianjiang River, a significant increase from the previous limit of 300 tons.

b. Challenges

Two challenges were encountered during the construction process.

1) Multiple factors made temperature control and crack prevention difficult, such as large pouring volume, complex structure, intensive constrained area, numerous exposed surfaces, and poor material properties.
2) Safety threats were associated with the unfavorable conditions in the large right bank slope adjacent to the plant, which include a weak interlayer exposed at the front edge, a steeply inclined joint surface at the back edge, and lateral gully development.

c. Solutions

1) An intelligent temperature control software system, analysis model, and hardware equipment have been developed based on project characteristics. This enables automatic sensing, transmission, and sharing of temperature control information throughout the entire process, including raw material pre-cooling, concrete mixing, concrete temperature control, water cooling and heat preservation, as well as intelligent control of various stages. This system enables comprehensive temperature control and crack prevention throughout all states of construction and management, utilizing the Internet and the Internet of Things, which effectively enhances the management of concrete-related construction.
2) A three-dimensional digital simulation model has been established based on field surveys and indoor tests to analyze the distribution of seepage within the slope and identify potential slope sliding modes. On this basis, the slope reinforcement scheme has been proposed and verified to ensure slope stability.
3) The project has significantly improved the flood control capacity of the middle and lower reaches of the Xijiang River and the Pearl River Delta, securing water supply for both life and agriculture. The flood control standard of Wuzhou City in Guangxi Province has been increased from a 50-year to a 100-year return period. The response time for emergency water diversion in Macao, Zhuhai and other cities has been reduced from 7–10 days to 3 days. The issue of water shortage for 80,000 hectares of arable land in central Guangxi has been resolved.

(5) Xiaolangdi Water Conservancy Hub Project

a. Background

The Xiaolangdi Reservoir is located on the main stream of the Yellow River, 40 km north of Luoyang City in Henan Province. This regulating reservoir controls 92.3% of the total area and nearly all sediment runoff in the Yellow River Basin. Put into operation in 1999, the Xiaolangdi Reservoir has a total capacity of 12.65 billion m^3 and a regulating capacity of 4.05 billion m^3. The project has multiple functions, including flood control and mitigation, sediment reduction, water supply, irrigation, and power generation.

The Yellow River is the second-longest river in China and the most sediment-laden river in the world. It has a multi-year average sediment content of 35 kg/m^3 and an average annual sediment load of 1.6 billion tons. Due to a serious imbalance between water and sediment, the lower reaches of the Yellow River were continuously chocked up, elevating the riverbed higher than the surrounding fields, creating a suspended river. As a result,

these areas are prone to overflow, siltation and flooding, which pose serious threats to the lives and property safety of people in Henan and Shandong Provinces.

Before the completion of the Xiaolangdi Reservoir, the lower reaches of the Yellow River continued to silt up, leading to river channel shrinkage and a reduction in overflow capacity. The flood control situation was grim because even a small water flow could lead to serious disasters. After the Xiaolangdi Reservoir was put into use, the bankfull flow in the lower reaches of the Yellow River increased from less than 2,000 m^3/s to 4,500 m^3/s, due to the flushing of the downstream channels over more than 20 years through water and sediment regulation. The project effectively reduces the risk of flooding in the lower reaches of the Yellow River, supporting the strategy of ecological protection and high-quality development of the Yellow River Basin.

b. Challenges

The Xiaolangdi Reservoir, as a regulating reservoir, plays a great role in harmonizing the relationship between water and sediment in the lower reaches of the Yellow River. However, it faces multiple challenges in sediment regulation and control.

1) It is challenging to regulate the substantial amount of sediment entering the reservoir due to the interdependent relationship between maintaining the reservoir's regulating capacity and guaranteeing the flood control safety of downstream rivers.
2) Without adequate flushing capacity to remove sediment that settles slower than water flow, a large amount of sediment accumulates in the reservoir area, resulting in a notable decrease in the reservoir's capacity to regulate water flow.
3) Clear water is likely to flow out of the reservoir due to hydraulic flushing and desilting within a limited scope. The kinetic energy of water flow is not fully utilized, resulting in a waste of water resources.

c. Solutions

1) The prototype testing and practice of water and sediment regulation have been conducted on a large scale, leading to the establishment of the theory of water and sediment regulation of the Yellow River. This has paved the way for a new management approach for the Yellow River. Thanks to water and sediment regulation, the riverbed of river channels in the lower reaches of the Yellow River has been lowered by more than 2 m on average through continuous flushing. The siltation morphology of the Xiaolangdi Reservoir has been effectively adjusted, as well as the cross-section morphology of downstream river channels. The overflow capacity of the main channels in the lower reaches of the Yellow River has been dramatically increased while preserving the storage capacity of the Xiaolangdi Reservoir. This equilibrium of sediment between the reservoir and downstream rivers plays a significant role in safeguarding the production and livelihoods of the people along the Yellow River .
2) The relationship between the traceable scouring volume and the kinetic energy of water flow has been established. A suite of hydrodynamic sediment regulation techniques has been developed to improve the efficiency of hydraulic sediment discharge, such as dynamic regulation techniques for upper limits of reservoir water level based on short- and medium-term runoff and sediment forecasts, spatial and temporal superposition techniques for efficient sediment discharge of mainstream and tributary reservoirs, and docking techniques for sediment dynamic regulation and water storage and discharge of mainstream and tributary reservoirs.

3) A water and sediment regulation technology, featuring jet flushing and pneumatic disturbance, has been developed to reduce sediment load during the clear water period. The key technical parameters of jet flushing and pneumatic disturbance have been optimized. Based on integrated research and development efforts, a series of techniques and equipment have been introduced for these two robust artificial measures. A supportive scheme involving robust artificial intervention has been proposed for the dynamic regulation of reservoir sediment. This scheme takes into account boundary conditions, regulation modes, as well as spatial and temporal variations between the mainstream and tributaries of the Yellow River. By harnessing the full kinetic energy of water flow, the amount of water used for sediment discharge has been minimized.

3. Case Studies Detail of the Projects

(1) Basin scale ecological restoration and ecological water replenishment in the Yongding River

a. Description

Yongding River, as a tributary of the Haihe River in North China, is one main stream within the Haihe river system and a prioritized factor in the Beijing-Tianjin-Hebei Integrated Development Plan. It is a natural corridor running through the Beijing-Tianjin-Hebei Ecological Functional Area, and a vital water conservation area forming a ecological barrier for this city cluster. The Chinese government plans to revive the Yongding River by making it "Flowing, Green, Clean and Safe" (FGCS), in an effort to reproduce its natural scenery featuring rivers with clear water , lakes rippling with waves, green trees stretching along the river banks and urban-rural integrated landscape.

Due to the extensive exploitation and utilization of the water resources, some sections of the Yongding river have dried up for years, and ecological functions of the river corridor have been greatly damaged. It is much-needed, therefore, to carry out research on ecological restoration strategies, key technologies and schemes in reconstructing the Yongding River ecological corridor in terms of morphological reconstruction, water quantity assurance, and water quality improvement, so the FGCS goals as well as ecological connectivity and restoration of the river corridor can be achieved.

The research team from the China Institute of Water Resources and Hydropower Research (IWHR) focused on the Yongding River (Beijing section) as a key demonstration area, conducting technological studies and comprehensive demonstration on optimizing multi-source ecological flow regulation and constructing green ecological corridors. To achieve the goal of a healthy river with clean water, key technologies have been developed, including green ecological corridor construction in the sand-laden dried-up river courses, ecological water quality and quantity assurance for water-deficient rivers in North China, and ecological function enhancement of large-scale stagnant artificial landscape water bodies (ALWs). A range of schemes have been developed, covering function optimization and comprehensive protection for the mountainous section of the Yongding River, ecological flow in the Yongding River, unified allocation and dispatch of ecological water use in the mountainous section of the Yongding River, ecological function optimization and enhancement of ALWs along the Yongding River (Beijing section), emergency response to algal blooms in ALWs, improvement and allocation

of landscape unit for green ecological river corridors, risk control of multi-type water sources and water quality and optimal regulation of ecological water replenishment system, and medium to long-term scheme for green ecological corridor construction. Then, demonstration site was constructed to test on key technologies for green ecological corridor construction of sand-laden dried-up river courses and ecological function enhancement of large-scale stagnant ALWs, marking the first demonstration site on restoration techniques of large-scale and heavily degraded river corridors. This initiative underpinned the ecological restoration efforts in the Yongding River (Beijing section) and the full recovery of water flowing uninterrupted in its entire course into the sea.

b. Challenges

1) To restore the natural flow of the Yongding River comprehensively, it is essential to develop key technologies on rebuilding green ecological corridors for the sand-laden dried-up river courses;
2) In case of limited water resources for ecological water replenishment, more scientific and rational approach for water supply and distribution is required. It is important to accurately allocate and scientifically dispatch water at basin scalue, so that different water sources can be used properly for ecological water replenishment;
3) It is necessary to maintain the water quality and water ecosystem of urban ALWs replenished by reclaimed water.

c. Solutions

1) To meet the technological demand of "restoring a running river", key technologies of reconstructing the green ecological corridor in the sand-laden dried-up river courses have been proposed, including improvement and allocation of ecological landscape unit for green ecological river corridors, construction of ecological riparian zones, restoration of diversified aquatic habitats, and river morphology reconstruction. Further, innovative ecological corridor restoration strategies have been proposed for sand-laden dried-up river courses, as well as technical parameters and schemes. These outcomes have greatly underpinned the ecological restoration practices in the sand-laden sections of the Yongding River.

IWHR has developed technologies for refined analysis of landscape unit evolution of river corridors, and proposed ecological corridor restoration strategies for sand-laden dried-up river courses. With technical breakthrough in analyzing the historical landscape of dried-up rivers, key components such as types, proportions, and spatial distribution of various landscape units before the river was dried up have been defined. Moreover, the critical landscape elements resulting river system degradation has been identified. Quantitative analysis of historical distributions and morphological features of floodplains, river islands, and water bodies, as well as their deviation status before drying up, has provided a quantitative understanding of morphological features of river courses before and after the drying up period. A historical reference system of river corridor landscape before the drying up period has been set up. IWHR has also proposed an analysis technique based on the historical references to identify key factors and optimize the construction of landscape units for green river corridor; and formed an optimal scheme for constructing ecological landscape units of the 170 km green ecological river corridor. On this basis, innovative strategies on ecological corridor restoration have been proposed for sand-laden dried-up river courses, through artificial channeling, natural development, and ecological succession. The strategies fill the gap in technical theory for the natural restoration and resilient regeneration of green river corridor landscape of sand-laden dried-up river courses in North China. These have been integrated into the comprehensive management

plan for the Yongding River, contributing to significant adjustments of the ecological restoration plan for dried-up sections of the Yongding River.

IWHR has proposed a technical roadmap for river corridor restoration that shapes and reconstructs river morphology by hydraulic desiltation based on artificially channeled ecological water replenishment. The technical principle of naturally reshaping river morphology has been introduced through hydraulic desiltation, involving artificial means to carve paths and guide the flow via water. In terms of hydraulic desiltation, techniques have been introduced for nesting diverse high-permeability landscape units into the river corridor, restoring water flows, and carrying out impact simulation and analysis. Specifically, this includes analyzing the seepage mechanism of sand-laden and dried-up river courses, determining riverbed substrate permeability parameters in the process of ecological water replenishment, and then developing techniques for integrated simulation of river flow and seepage flow nested within non-river-corridor landscape units (such as gravel pits, golf courses, and terrestrial vegetation), which enables long-term simulation of ecological water replenishment in old dried-up rivers. Additionally, technologies for portraying the hydraulic connection and process of surface groundwater flows in highly permeable sand-laden river courses have been developed, along with techniques for analyzing the impact of ecological water replenishment in the Yongding River on groundwater environment and urban safety. These efforts provide insights into the extent and trends of the impact of ecological water replenishment on groundwater environment and safety. To guide the water flow, techniques and parameters have been established for predicting the morphological evolution of river corridor driven by artificial discharge pulse. Specifically, a comprehensive technique for predicting the morphological evolution of dried-up river courses has been formulated, integrating physical and mathematical modeling, along with multi-factor monitoring of the entire process of the ecological water replenishment. The technique reveals the patterns of water flow progression and riverbed evolution in ecological water replenishment. Subsequently, a technical scheme that reshapes river morphology by artificial discharge pulse has been designed. First, creating an artificial flood process by means of high-flow pulse is the best way of ecological water replenishment to rapidly restore the natural state of river corridor and maximize the retention of near-natural evolution of river channels. The recommended discharge of artificial pulse should be equivalent to 1-3 years of peak flow. Second, artificially pulsed water replenishment can be carried out according to the peak flow in spring and autumn, with reference to historical hydrological data from the 1960s. Based on historical quantitative analysis of river morphology in 1933 and 1967, artificially pulsed water replenishment, combined with moderate bank protection, will enable dried-up river sections to naturally evolve to or approach the state of the 1960s before it was dried up, with acceptable impact overall on the groundwater environment in the next decade.

The technology of ecologically resilient riverbank construction for sand-laden dried-up river courses has been developed, capable of withstanding hydrological stress. This includes determining optimal way to configure low-resistance flow, selecting the best plant species and ecological bank protection forms, and establishing a clear spatial layout strategy for ecological riverbank construction in both horizontal and vertical directions. A progressive ecological riverbank construction system has been built up for sand-laden river corridors, transitioning from stable bank slopes and flood control embankments, to soil improvement, habitat enhancement, backwater prevention and landscape recovery. This system provides input in the ecological restoration theory for riverbank ecosystems of the sand-laden river courses in North China. More than five indigenous plant species have been selected and cultivated, along with the screening of five ecological

methods for protecting sand-laden riverbank, and the development of five slow-seepage composite vegetation configurations.

A multi-dimensional habitat restoration technique for sand-laden river environments has been proposed based on the theory of temporary storage. Key locations have been precisely pinpointed for ecological restoration in sand-laden river corridor. River ecosystems have been constructed, ranging from water flow and geomorphology to river pattern and morphology, from substrate to migration and transformation of biogenic elements, and from biogenic elements to food chains and food networks of plants and animals. This has resulted in diverse aquatic habitats in sand-laden rivers, featuring diversity in forms, structures, species and functions. Breakthroughs have been made in tackling with challenges such as water and fertilizer loss and green plant transplantation in sand-laden river corridors. Four kinds of practical and cost-effective ecological seepage control materials have been developed, along with four species of emergent aquatic plants and one floating-leaved plant being identified. These results have contributed to the technology of restoring diversified habitats for water-scarce and dried-up river corridors in the northern region.

2) To meet the technological demand of "increasing water quantity", technologies have been introduced for guaranteeing ecological water quantity and quality in water-scarce rivers in North China. These include the development of ecological flow determination technique using a "four-division + coordination" approach, water quality risk assessment of diverse water sources and water purification techniques of wetlands. The optimal allocation technique of river basin water resources from various sources has been formulated to ensure ecological flow. Moreover, the joint dispatch method of reservoirs for ecological water replenishment has been proposed. Together, these methods solved the problems of precise allocation and optimal regulation of water resources at the basin scale, greatly supporting the ecological water replenishment in the Yongding River.

Regarding the ecological flow determination, IWHR has initiated the "four-division + coordination" technology system to determine ecological flow that can meet multiple ecological targets, while coordinating the "three water uses" including ecological water use, industrial water use and household water use. Research methods have been introduced for identifying ecological protection targets and their eco-hydrological response relations, so as to cope with obstacles such as insufficient water resources in water-scarce regions in North China, the imbalanced "three water uses" and different demands from various ecological protection targets. The "four-division + coordination" system for ecological flow determination, encompassed zoning for ecological flow management, categorizing of ecological protection targets and key flow components, phasing of eco-hydrological rhythms and target years, grading of early warning for implementation, and coordination between upstream and downstream of the river basin and coordination among the "three water uses". This system helps overcome the difficulties of technically determining the minimum ecological flow responding to the ecological processes of rivers and lakes. Furthermore, the typical ecological flow process of cross sections in the Yongding River Basin that meets different ecological targets have been presented.

With regard to water quality of diverse water replenishment sources, IWHR has introduced the ecological risk assessment technology, capable of identifying key differences in water quality indicators among diverse water sources and the main limiting factors affecting eutrophication and biotoxicity, and put forward risk control strategies accordingly. A multi-mode water purification system for ecological water replenishment sources, and a comprehensive technical system incorporating rapid infiltration and ecological treatment to purify urban

stormwater discharge into rivers, have been developed. These have tackled the challenges related to the coupled configuration of high-efficiency functional fillers in wetlands, construction of wetland substrate particle size distributions, infiltration system construction and water purification for rivers. A multi-mode ecological water replenishment water source purification system tailored to landscape, water quantity, and water quality requirements, has been formulated, along with a layout plan for wetland construction in the Yongding River.

A technical system for water resources allocation in North China has been established, focusing on ecological flow regulation and integrating various water sources such as local runoff, reclaimed water, inter-basin transferred water, and stormwater. The system has enabled the refined and precise allocation of water resources, improving the efficiency of water use and maximizing the ecological benefits of water resources across the basin. Technology and scheme have been introduced for optimal allocation and comprehensive regulation of water resources to ensure the ecological flow for typical rivers and lakes in North China, while considering multiple water sources, objectives, and scenarios. The scheme has presented, for the first time, ecological water demand targets for aquatic ecological protection by levels and sections of rivers; underlined more refined targets and constraints of basin water resource allocation; and initiated innovative, optimal, and refined water resource regulation under multi-source and multi-objective scenarios. As a result, the water shortage rate of socio-economic water use outside river channels in the Yongding River basin is limited within 12%, regardless of various hydrological conditions, thus benefiting the allocation and regulation of water resources across the basin. In addition, techniques and scheme have been proposed in ecological water replenishment from the Yellow River and joint dispatch of reservoirs, including a more refined hydrodynamic model based on the infiltration patterns of substrate specific to northern rivers. These have greatly underpinned the ecological water replenishment in the Yongding River.

3) To meet the technological demand of "improving water quality", ecological function enhancement technologies and schemes have been proposed for large-scale stagnant ALWs, in particular bettering the ecological functions of stagnant ALWs in the Yongding River.

Taking into account the life-cycle needs of various vegetation, IWHR has developed technologies for optimizing and adjusting the ecological function units of ALWs in terms of water quantity, water quality, aquatic life, and habitat, enabling accurate identification of health risk factors in ALWs. Noting the characteristics of stagnant ALWs, IWHR has tracked and monitored the dynamic changes of nutrients in plants, and drafted an innovative gradient table for submerged vegetation, reflecting the different state of vegetation growth during their life cycle and their characteristics in nutrient absorption and release. Drawing upon sufficient investigations and studies, evaluation techniques for landscape water bodies and identification techniques for health risk factors in ALWs have been formulated.

The characteristics of stagnant ALWs in terms of hydrodynamic conditions, water quality, and aquatic biological community response have been revealed. Technical experiments centering on flow field disturbance have been carried out to identify the typical biological chains, nutrient structures and main functional groups in stagnant ALWs. Key parameters were optimized and technical combinations were made for various in-situ purification technologies, including composite ecological floating wetland, water cycle reoxygenation, microbial fungicide, artificial water plants, and underwater forest construction. On this basis, technologies for flow adjustment, zoning-based hydraulic regulation and water purification of stagnant ALWs have been developed, and schemes for hydraulic regulation and in-situ purification technical roadmap in ALWs have been proposed.

In view of the poor hydrodynamic conditions in ALWs and strong disturbance to water quality caused by multi-source water replenishment, an early warning and emergency response method to algal bloom have been established for ALWs based on the main driving factors of algal bloom formation and decay processes. A comprehensive online monitoring and early warning system for water quality has been constructed by applying biological early warning technology of algal bloom, which integrated multiple parameters of algal bloom. By coupling the chemical-biological-ecological response model and biological early warning algorithm, this system enables rapid early warning and efficient emergency response to algal bloom in ALWs.

4. Future Plan

As climate change intensifies, the challenge of addressing water-related issues, both new and old, remains daunting. China needs to continue efforts in improving the flood and drought prevention systems, advancing water conservation, optimizing the allocation of water resources, and protecting and managing the ecosystems of rivers, lakes and reservoirs. China is dedicated to promoting the high-quality development of water and enhancing the capability to safeguard water security.

(1) Strengthening flood and drought prevention

We will step up improving the flood control engineering system, rainfall monitoring and forecasting system and flood and drought prevention working system. We will adhere to the principle of "put preparedness first", focus on the prevention and extend the range of safety nets. By preparing for the disasters with more certainty and perspectiveness, the randomness and suddenness of floods and droughts risks could be better responded and prevented, thus minimizing the resulted disaster losses.

Adhering to the principle of "prevention first", we will focus our efforts on prevention by extending the line of defense, and respond to the suddenness and uncertainty of flood disasters with far-sighted workflow and targeted control measures. We will continue to reinforce the three lines of defense against floods and droughts, including basin flood control works, rainfall monitoring and flood simulation and forecasting, and emergency measures.

(2) Developing major projects under the national water network

We will accelerate the construction of a modern national water network that is safer, more efficient and smarter, thus supporting the planning and construction of water networks at provincial, municipal and county levels to enhance the capacity to guarantee water security.

(3) Revitalizing rivers and lakes

We will strengthen the ecological flow management of rivers and lakes, consolidate the protection and management of major rivers, lakes and reservoirs, and shore up the comprehensive management of soil erosion and groundwater overexploitation. We aim to keep rivers and lakes alive and healthy in functioning sustainably, and further promote the harmony between humanity and nature .

(4) Advancing digital water management

We will step up the construction of water monitoring system, and strengthen the digital management and intelligent simulation of river basins, water networks and water projects, to provide scientific and efficient decision-making tools for ensuring water security.

(5) Establishing and improving water conservation system and policies

We aim to establish and improve the system for initial allocation and trading of water rights, and enforce the supervision and rigid constraints on water resources. We will continue to implement the national water conservation initiatives, and bolster the utilization of non-conventional water resources, towards a water-saving society with higher levels of conservation, intensive and safe utilization of water resources.

Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

East and North East Asia

Japan

Ministry of Land, Infrastructure, Transport and Tourism, Japan

1. Introduction

(1) Water Resource Situation in Japan

Total precipitation in Japan is about 660 billion cubic metres, nearly 35% of which are estimated to be evaporated and the remaining 430 billion cubic metres is the logical maximum water resource in Japan. Actual water consumption in Japan is 78.5 billion cubic metres, of which 14.8 is used for domestic purposes, 10.3 for industrial purposes, and 53.3 for agricultural purposes. Japan needs and has constructed water resources infrastructure to ensure stable water use, due to the high variability of daily or monthly river water discharges, even though Japan's total precipitation is comparatively high compared to other countries.

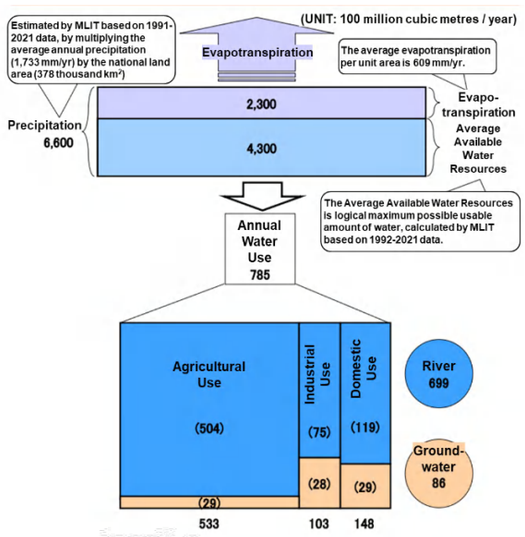


Figure 1.1 Overview of the Water Resources in Japan

(2) Flood Risk Reduction Policy Changes in Japan

The frequency of short-duration heavy rainfall (over 50 mm/hour) has increased by about 1.4 times in 30 years. As a result, natural disasters have occurred almost every year in Japan in recent years.

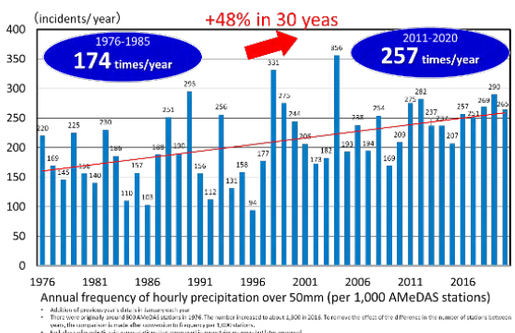


Figure 1.2 Increase of heavy rainfall in Japan

(3) Revision of the River Plans to Take Account of Climate Change

The River Improvement Plans have been (or will be) revised to take account of climate change. The current river plans, which are based on past records of precipitation and tidal levels, will be gradually revised to take into account the effects of climate change. The estimation of the rainfall is along with a scenario that keeps global average temperature increase to well below 2°C (the target scenario of the Paris Agreement on Climate Change), precipitation is expected to increase by a factor of 1.1 in many river basins in Japan.

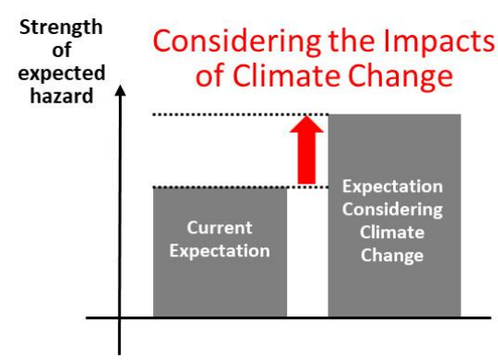


Figure 1.3 Concept of river plan revision

2. Selected Completed Projects

(1) River Basin Disaster Resilience and Sustainability by All

a. Description

Japan has introduced a new flood and river management policy under the concept of "River Basin Disaster Resilience and Sustainability by All" to achieve comprehensive and multi-layered water-related disaster risk reduction strategy considering climate change, which includes the shift to mainstream disaster prevention and mitigation strategy into for society and the promoting the transition to basin-wide flood management with all relevant stakeholders, including businesses and households.

b. Challenges

To promote the above policy, the existing challenges have been streamlined into three pillars, which include the impact of climate change, changing social trends, and technological innovation. Climate change urges river managers strengthen the measure for early infrastructure improvement to secure flood safety in the basin. The social demand under the depopulating society requires to achieve the safe and secure urban planning under the concept of "Compact Plus Network". The innovation, especially in the field of information and communication technology, such as 5G, AI, big data, should be more extensively leveraged for disaster risk reduction.

c. Solutions

The concept of "River Basin Disaster Resilience and Sustainability by All" includes measures to be implemented with the cooperation of all stakeholders. It includes flood control measures to be implemented by all stakeholders around river basins including the national government, prefectures, municipalities, private enterprises, and residents. And these measures should be implemented in all kinds of places around basins, around basins that include not only river areas and floodplains, but also catchment.

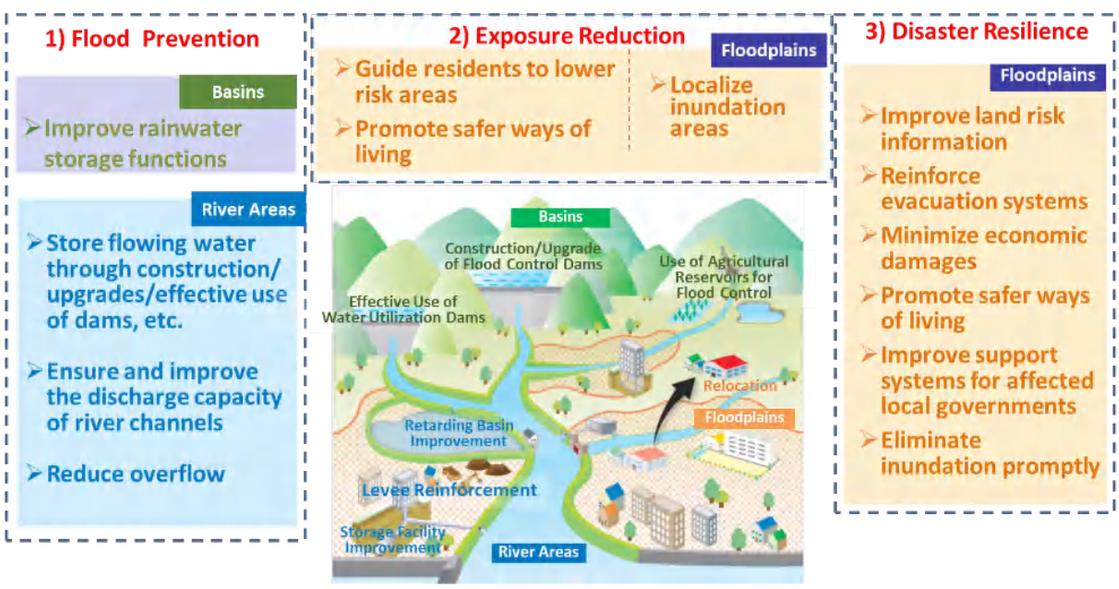


Figure 2.1 Concept of "River Basin Disaster Resilience and Sustainability by All"

(2) Case Study: Abukuma River Basin Flood Management Project

a. Description

In October 2019, Typhoon Hagibis hit a wide area of Japan, including the Abukuma River Basin, causing a severe flood disaster. The Abukuma River has a basin of 5,400 km², in the south of the Tohoku region of Japan.

b .Challenges

After the flood disaster, a basin-wide approach was needed to increase the flood resilience of the entire basin.

c. Solutions

After the flood disaster, an integrated basin-wide consensus was reached and an integrated plan was formulated.

(3) Dam Upgrading under Operation

a. Description

Downstream water levels can be drastically reduced by using upstream dams to store floodwater. Making full use of upstream dams is essential for flood risk reduction.

b. Challenges

Full use of upstream dams is essential for flood risk reduction. Various technologies to upgrade existing upstream dams without disrupting their operation will help to reduce the risk to the whole downstream area.

c. Solutions

Various dam upgrading projects are being carried out in Japan, including increasing total reservoir capacity, rapid flood control, flood capacity increase and sediment management.

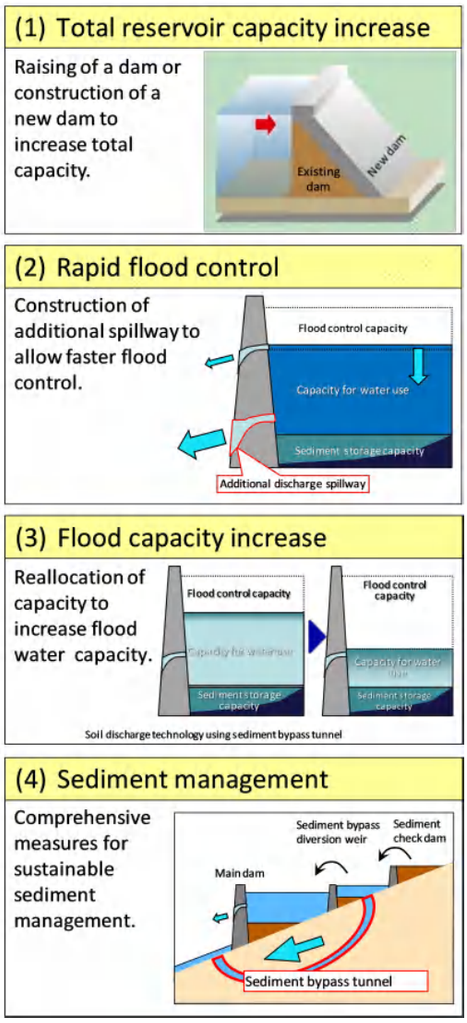


Figure 2.2 Concept of dam upgrading under operation

(4) Case Study: Kinugawa River Upstream Area Dam Group Networking Project

a. Description

The Kinugawa River, with a length of 177 km and a catchment area of 1,761 km², is a tributary of the Tone River, the largest river basin in Japan, located northeast of the Tokyo metropolitan area

b. Challenges

The Kawaji Dam (completed in 1983) and the Ikari Dam (completed in 1956) are located next to each other. Kawaji Dam has a smaller annual inflow but boasts a larger storage capacity. In contrast, the Ikari Dam, which was

finished in 1956, handles a larger annual inflow with a smaller capacity. Increasing the efficiency of both dams can increase the overall resilience of the basin in terms of both flood risk reduction and water resources management.

c. Solutions

The Kawaji and Ikari dams were connected (completed in 2005) to make full use of the capacity of two reservoirs. The Kawaji reservoir is larger but receives less rainfall, while the Ikari reservoir is smaller but receives more rainfall.

Figure 2.3 Overview of Kinugawa River Upstream Area Dam Group Networking Project

3. Detail of the "Abukuma River Basin Flood Management Project"

(1) Description

On October 12 to 13, 2019, Typhoon Hagibis made landfall and caused heavy rainfall over a wide area of Japan. In the upper Abukuma River Basin, the flood caused significant damage, including 31 breaches of national and prefectural levees, with record high water levels that rose very quickly and persisted for a long time. After four months of discussion, many stakeholders in the basin agreed on an integrated flood management project, including both structural and non-structural flood risk reduction measures.

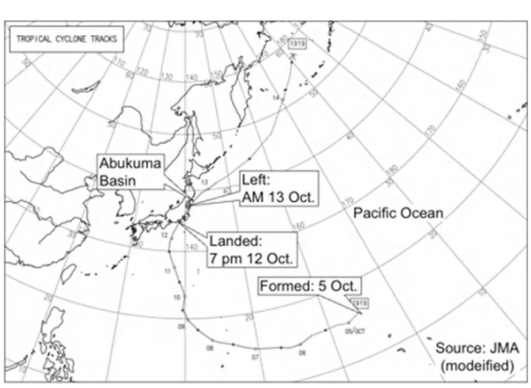


Figure 3.1 Overview of the Typhoon Hagibis

(2) Challenges

After observing the record flood, the challenges in the basin were officially agreed on December 3-4, 2019, which include insufficient infrastructure capacity, insufficient consideration of flood risks in urban planning, insufficient preparedness for evacuation assistance, and insufficient preparation to the backwater effect. The Integrated Flood Management Project has been formulated to address these challenges.

Figure 3.2 Flood inundation in Koriyama City

(3) Solutions

The Integrated Flood Management Project includes 1) river infrastructure improvement, 2) flood-risk-conscious land-use, 3) district-level adaptive flood evacuation plan, 4) backwater tributary preparedness, and 5) local municipal programs.

In 2021, after the implementation of “River Basin Disaster Resilience and Sustainability by All”, these measures in the Abukuma River Basin were more integrated under the new policy, and the revised plan was agreed by relevant stakeholders.

First, the river infrastructure improvement will expand the capacity of the river infrastructure to suppress flood peaks below the levee crest, even if the same flood, 7,400 m^3/s at Fukushima Observatory, occurs.

Second, to promote flood risk-conscious land use, integrated flood risk hazard maps were subsequently formulated, taking into account minor tributaries and drainage capacities that have not been well accounted for.

Third, to facilitate evacuation, Flood Timelines (FT), or Flood Disaster Response Plans with simple instructions on "when", "who" and "what to do" with a timeline prior to the flood event, were formulated by the municipalities under the project.

Forth, additional water-gauges and CCTVs have been installed on tributaries affected by backwater. The communities around the confluences were empowered to develop the district-level evacuation plan taking these into account.

In addition to the above project components, each municipality is to implement local programmes in coordination with the other components. For example, Date City has improved its disaster management system to share the information even in an emergency situation, and Koriyama City has formulated a 3D-based flood hazard map to raise public awareness.

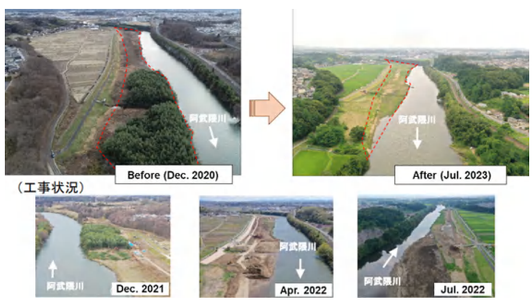


Figure 3.3 Riverbed improvement

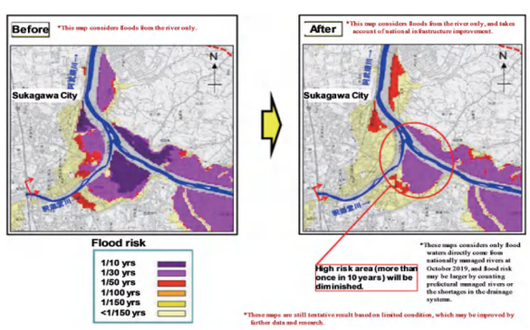


Figure 3.4 Expected outcome of the infrastructure improvement

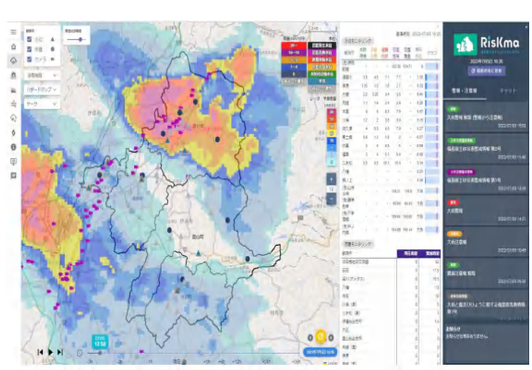


Figure 3.5 Improved disaster management system by Date City

Figure 3.6 3D-based flood hazard map by Koriyama City

4. Future Plan

(1) Kumamoto Initiative for Water

Based on the Japan's experience in the field of water-related disaster risk reduction and water resources management, Japan has announced the "Kumamoto Initiative for Water" at the 4th Asia-Pacific Water Summit, held in Kumamoto City, Japan.

Furthermore, H.E. Ms. KAMIKAWA Yoko, Special Envoy of the Prime Minister of Japan (now Foreign Minister of Japan), reiterated this Initiative at the UN Water Conference, held in March 2023 and emphasised the importance of the "by all" concept by introducing basin-wide flood risk reduction to address climate change risks.

Figure 4.1 Commitment by H.E. Ms. KAMIKAWA Yoko, at the UN Water Conference 2023

Based on this Initiative, Japan is making a proactive contribution to solving water-related social issues in the Asia-Pacific region by developing "Quality Infrastructure" using Japan's advanced technologies, by promoting public-private partnerships, and encouraging digitisation and innovation to solve social issues as a growth engine for sustainable development and the formation of a resilient society and economy.

The Initiative includes promoting the development of "Quality Infrastructure", contributing to filling observation data gaps, contributing to governance (systems, human resources and capacity), and using and expanding the Joint Crediting Mechanism (JCM) to promote both climate change adaptation and mitigation measures. It also includes measures to improve people's basic living environment by promoting the development of "Quality Water Supply Systems" and by promoting the development of "Quality Sanitation Facilities".

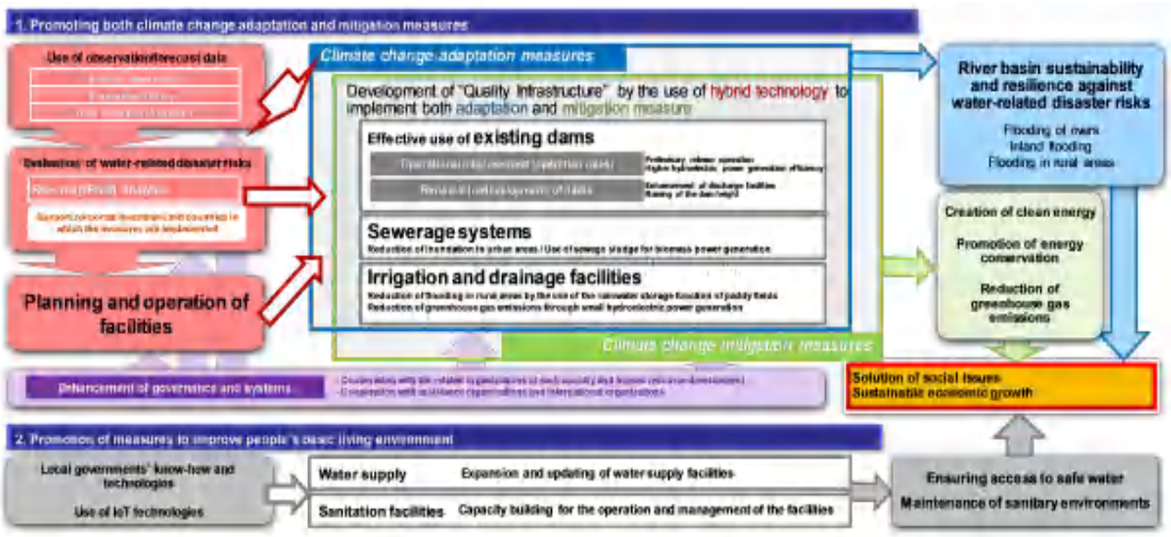


Figure 4.2 Overview of "Kumamoto Initiative for Water"

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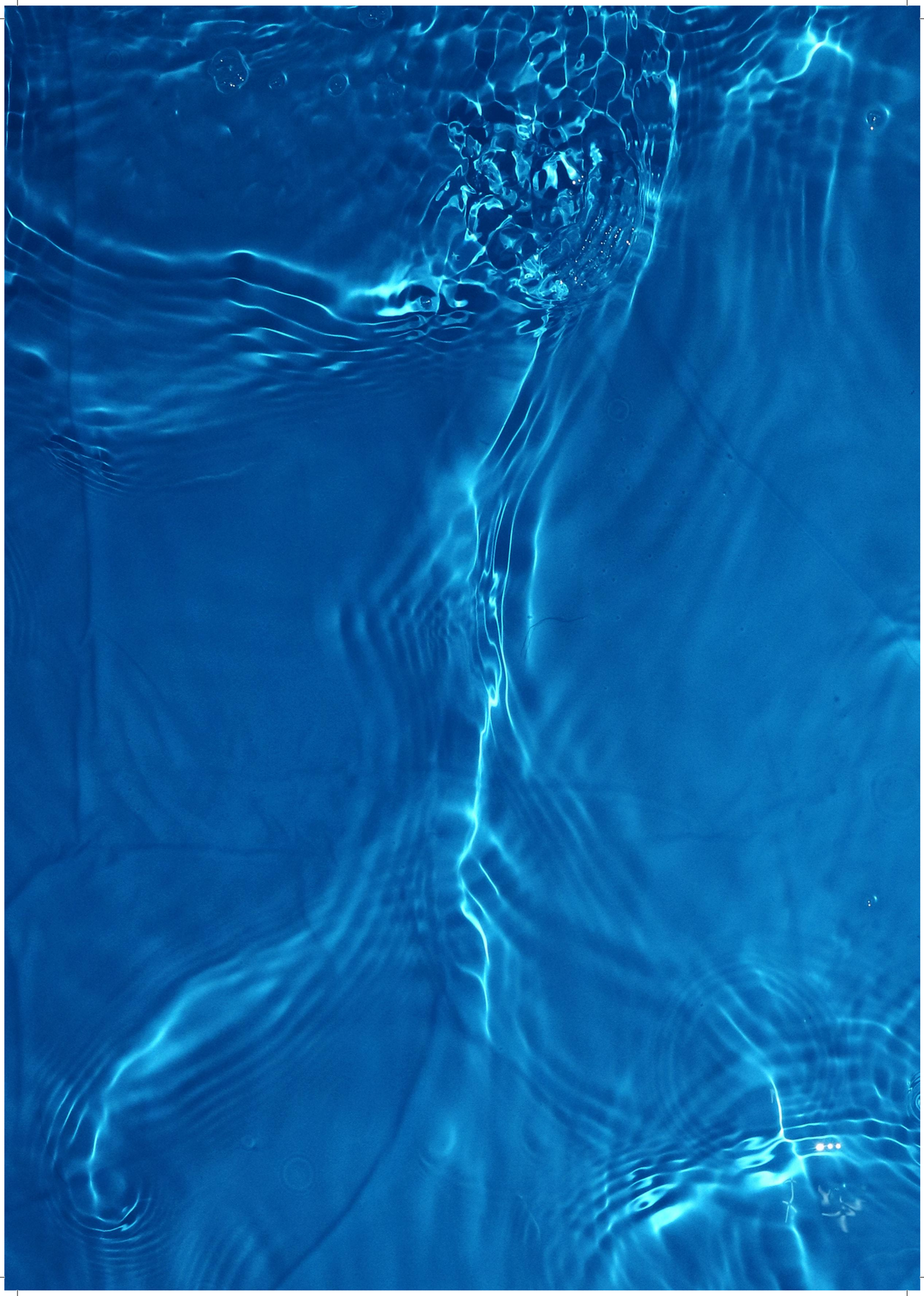


Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

East and North East Asia

Mongolia

Water Services Regulatory Commission
(WSRC)

1. Introduction

(1) Corrosion in the pipelines of Mongolia

Water pipelines in Mongolia play a crucial role in providing access to clean water, especially in urban areas where centralized water supply systems are essential to serve the population. The capital of Mongolia - Ulaanbaatar - has a second, third and fourth thermal power plants fed by a centralized heat supply system with 286.2 km of heat pipes with a diameter of 150-1200 mm, which is used to supply heat to 60,000 apartments and social housing.

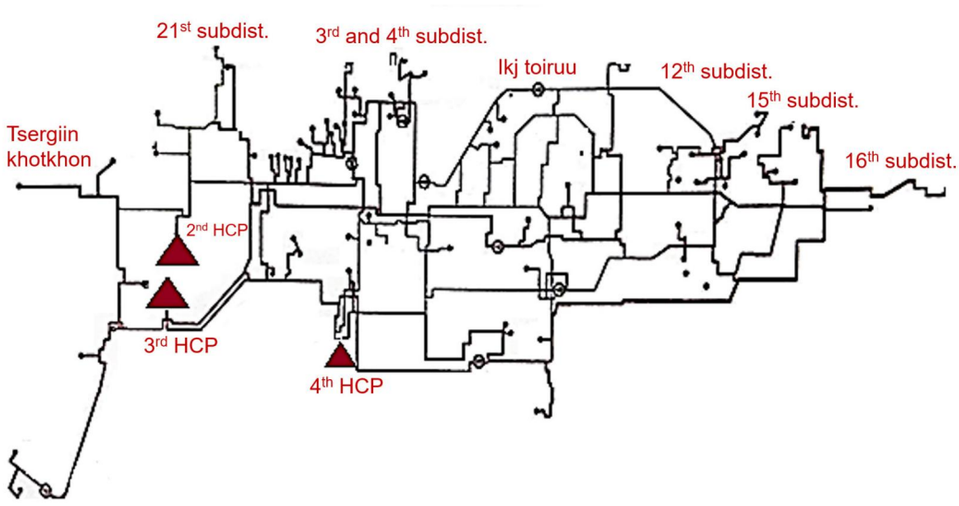
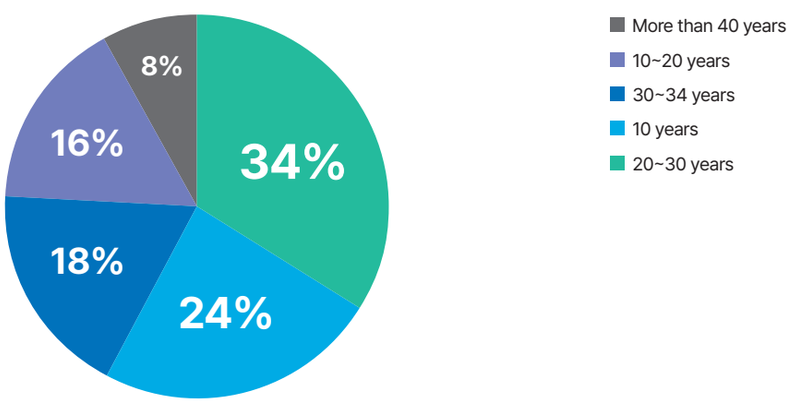


Figure 1.1 The central heating system of Ulaanbaatar city

Mongolia's central heating system has been struggling with rust problems for a long time. The corrosion of the pipelines is due to various factors related to the environment, infrastructure, socio-economic conditions in Mongolia and water hardness.

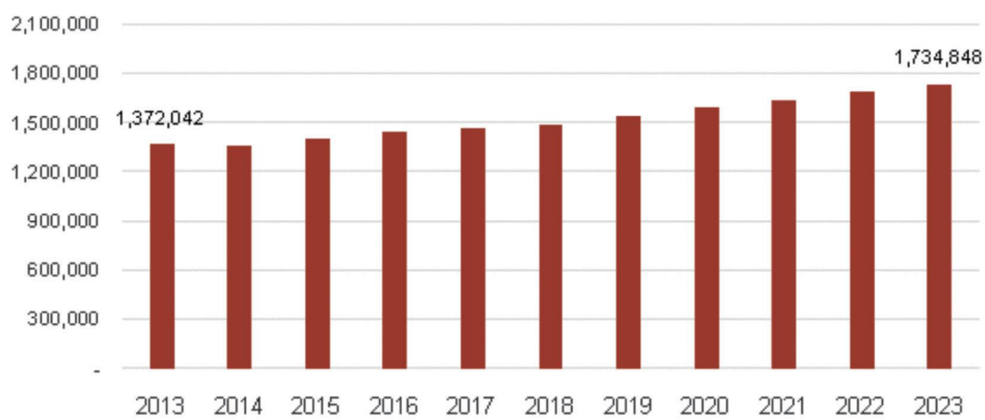
Outdated infrastructure: As urbanization in Mongolia has increased significantly since 1960s, the pipelines are up to 50 years old.



Graphic 1 Age of water pipelines

In Mongolia, the maintenance of water infrastructure is minimal due to limited resources and lack of technical expertise. The lack of consistent maintenance and inspection allows for uncontrolled corrosion in the pipes, leading to rust-related problems that affect water quality and reliability.

The heating and water supply systems are under considerable significant pressure: Heating and water supply are handled by an integrated system. As Ulaanbaatar and other major cities are experiencing rapid urbanization (Ulaanbaatar has seen a population growth of 26.44% in the past decade, the existing water infrastructure is under severe strain from the growing urban population. With the increasing demand for water, the older pipes are overwhelmed, leading to leaks, breaks and increasing corrosion, which exacerbates the rust problem.



Graphic 2 Population growth of Ulaanbaatar

Water with a high degree of hardness: Extensive water quality studies have been carried out in water quality, and surveys indicate that a significant portion of the population's drinking water is very hard and does not meet standard requirements. This high degree of hardness leads in particular to rust and limescale deposits in the pipes.

In Ulaanbaatar, 60 percent of the water supply network's useful life has been depleted, which leads to a challenging situation in terms of infrastructure maintenance. The pipes are increasingly vulnerable to corrosion and rust over time, which is exacerbated by insufficient maintenance resources and the inherent high hardness of the water

2. Selected Completed Projects

Professionals and organizations have attempted to address the pipeline issue; the optimal solution is to overhaul the entire system. Fully modernizing an outdated system is not financially viable for Mongolia. However, new technologies such as the Vulcan anti-scale electronic system have proven beneficial to Mongolia's water problems.

As one of the pioneering manufacturers with a presence in 70 countries, CWT has garnered a reputation for its expertise in addressing water quality issues. We tested this device in several locations in Ulaanbaatar.

The negative effects observed after the installation of the Vulcan anti-scale device at the test site. It implies that Vulcan is considered an effective solution to problems associated with rust and limescale deposits in water pipelines. The prospect of immediate results after a certain period of time indicates that Vulcan is seen as a fast and efficient solution to improve water quality in Mongolia.

Over the past two years, we have been engaged in projects in various locations in Mongolia, including apartments, private houses, bathhouses, universities, industries and mining operations.

(1) Apartments

a. Description

There are 60,000 apartments in Ulaanbaatar, most of them facing issues with rusty water. Most people living in apartments drain the water until the rusty, metallic colour of the water coming out of the faucet is gone. However, reducing surface rust on water pipelines and fittings can save 10-15% of the excess water that would otherwise be wasted.

b. Challenges

The challenges outlined in the apartment highlight the significant impact of limescale and rust on the infrastructure of the facility. Managing a large building requires constant monitoring of the infrastructures. The apartments need to clean the plate heat exchanger at least twice a year.

c. Solutions

The installation of the Vulcan anti-scale system has provided an effective solution to the limescale and rust challenges in the apartments. Vulcan gently reduces the existing deposits in the piping system. The scale build-up process is reversed and the pipes gradually become cleaner again. This descaling process does not block up pipes or drains as the treated crystals are microscopic in size and are washed away with the water.

- Reduces scale deposits in the piping system
- Eliminate the need for cleaning the plate heat exchanger as scale formation ceased.
- Less time and effort for building and facilities.
- Machinery and equipment perform more reliably.

3. Test Projects in Mongolia

(1) Uvurkhangai Bathhouse

a. Description

Uvurkhangai is one of the 21 aimags (provinces) of Mongolia, located in the south of the country and has a high water hardness. The bathhouse has 15 baths that use 100-150 tons of water per month.

b. Challenges

The challenges outlined in the bathhouse illustrate the significant impact of limescale and rust on the facility's

infrastructure. The frequent need for maintenance and replacement of components is an indication of the severity of the problems caused by these deposits. Particular challenges include:

- Frequent pump replacement: The circulation pump needs to be replaced every 4 months, and the vacuum every 3 months.
- Annual replacement of the piping: The need to replace the pipework annually underlines the extent of limescale and rust buil-up in the pipes. This not only incurs maintenance costs, but also disrupts regular operation and affects the overall efficiency of the bathhouse.
- Regular cleaning of other parts: Additional components such as reserve tanks need to be cleaned monthly.

c. Solutions

The implementation of the Vulcan anti-scale system has effectively addressed the limescale and rust challenges in the bathhouse.

- No limescale deposits: The Vulcan anti-scale system has successfully eliminated limescale deposits throughout the piping system;
- Minimized operating and maintenance costs: With the Vulcan system, components such as circulation pumps, vacuum pumps, and pipelines need to be replaced less frequently;
- Maximized service life of appliances and systems;
- Less time and effort for cleaning.

As mentioned above, the presence of limescale and rust deposits in the pipelines shows the significant impact on the facility's infrastructure, where frequent replacement of pumps and pipelines and the regular cleaning of other parts was necessary. The installation of Vulcan in these pipes helped to solve these problems. The difference between the service life conditions of the pipelines before and after the installation of Vulcan is shown in Figure 1.

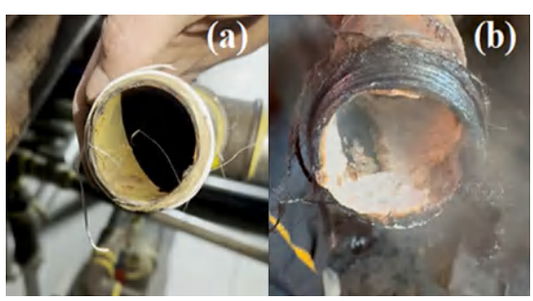


Figure 3.1 The service life of the pipeline is one and half year with Vulcan. (b) The service life of the pipeline is one year without using Vulcan.

(2) Apartment town in Yarmag area

a. Description

The Yarmag area in Ulaanbaatar, Mongolia, is struggling with water problems due to high level of water hardness. This is an example of indicative challenges related to water scarcity and infrastructure in rapidly growing urban areas.

b. Challenges

High water hardness can lead to various issues, including the formation of rust in the piping systems. In the Yarmag area, this problem occurs, resulting in rusty water coming out of the water pipes used by residents.

c. Solutions

It appears that the installation of the Vulcan anti-scale system has led to several positive outcomes and improvements in the water system and associated infrastructure. The benefits observed include:

- Reduced scale deposits in the piping system;
- Reduced of iron content in 1 mg/l water reduced by a factor of 10 within two months;
- Increased reliability of machines and systems;
- Less time and effort for maintenance of buildings and facilities;
- Faster cleaning of kitchens and bathrooms;
- Filters, shower heads and sinks stay cleaner;
- Significant savings on cleaning agents.

Vulcan was installed in the water pipelines in this residential town on August 20, 2022. After the installation of Vulcan in the water pipes in this residential town, remarkable results were achieved (see Figure 2). In Figure 2(a) we show the image of the rusty water in the bathtub before the installation of Vulcan. In the other two pictures, clear changes can be seen after 20 and 35 days after installation.

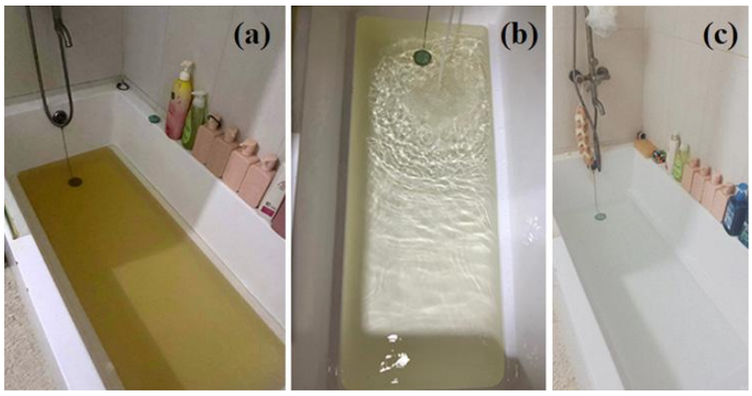


Figure 3.2 The comparison of the amount of rusty water in the bathtub
(a) before (b) after 20 (September 10, 2022) and (c) 35 (October 5, 2022) days after the installation of Vulcan.

The water analyses before and after the installation of Vulcan were carried out in the HANLAB accredited laboratory in Mongolia. The water analysis report shows that the concentration of iron in tap water before the installation of Vulcan was 0.45 mg/l (Table 1), while it decreased to 0.04mg/l after the installation (Table 2). The concentration of the other chemical elements in the water remained unchanged.

Table 3.1 The water analysis report of the tap water in the apartment
town of Yaarmag, before the installation of Vulcan. Date: August 20, 2022.

#	Parameters	Content per l	Technical specification	Test results
1	Iron, Fe	mg/l	0.45	0.3
2	Manganese, Mn	mg/l	0.02	0.1
3	Molybdenum, Mo	mg/l	<0.005	0.07
4	Nickel, NI	mg/l	<0.005	0.02
5	Lead, Pb	mg/l	<0.01	0.01
6	Antimony, Sb	mg/l	<0.01	0.02
7	Selenium, Se	mg/l	<0.05	0.04
8	Strontium, Sr	mg/l	0.07	2.00
9	Uranium, U	mg/l	<0.50	0.03

Table 3.2 The water analysis report of the tap water in the apartment town of Yaarmag, after 67 days of the Vulcan's installation.

#	Parameters	Content per l	Technical specification	Test results
1	Iron, Fe	mg/l	0.04	0.3
2	Manganese, Mn	mg/l	0.02	0.1
3	Molybdenum, Mo	mg/l	<0.005	0.07
4	Nickel, NI	mg/l	<0.005	0.02
5	Lead, Pb	mg/l	<0.01	0.01
6	Antimony, Sb	mg/l	<0.01	0.02
7	Selenium, Se	mg/l	<0.05	0.04
8	Strontium, Sr	mg/l	0.07	2.00
9	Uranium, U	mg/l	<0.50	0.03

The evidence from the two previous test projects indicates that the introduction of anti-scale electronic systems has effectively halted rust formation in pipelines. This conclusion underscores the transformative impact of innovative technology on pipeline management and corrosion prevention.

4. Future Plan

(1) Rust Challenges

Certainly, the formation of rust in pipelines can pose significant challenges and risks for people in Mongolia, as in many other regions of the world. Rust in pipelines can lead to various problems, including Pipeline Degradation, Increased Maintenance Costs, and Environmental Impact.

(2) Future Action

By adopting a phased approach to modernising the water system and leveraging technologies like Vulcan to combat rust, Mongolia can make significant strides in improving water quality and protecting public health. This proactive approach requires coordinated efforts, investment, and commitment from all stakeholders, but the long-term benefits of clean and safe drinking water for the population justify these efforts.

5. References

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Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

East and North East Asia

Republic of Korea

K-water

1. Introduction

(1) Digital Transformation of Water Management Systems

With the recent impacts of climate change, including increased flooding due to concentrated rainfall and droughts resulting from rising temperatures, water-related disasters are persistently on the rise. Furthermore, as the increase in forecast uncertainty due to climate change has a significant impact on water supply, the importance of tap water services, which are directly related to people's lives, is increasing day by day.

In response to the intensified occurrences and severity of concentrated rainfall and extreme droughts caused by the climate crisis, there is an urgent need to swiftly and accurately monitor and predict actual situations to respond to water-related disasters proactively. Reevaluation and improvement of existing water management systems and frameworks are imperative to realize a safe nation resilient to water-related disasters amidst climate crisis-induced uncertainties.

Moreover, countries worldwide are accelerating digital transformation across industries to adapt to paradigm shifts caused by the COVID-19 pandemic and overcome economic crises.

K-water has integrated innovative technologies of the Fourth Industrial Revolution into water management in line with the digital transformation era. Efforts have been made to establish a water management system based on digital innovation technologies to address the complexity and uncertainty of water management caused by the climate crisis and enhance efficiency and reliability.

2. Selected Completed Projects

(1) Digital Twin Water Management Platform (Digital GARAM^{+})

a. Description

Digital twin technology represents the convergence of various technologies, virtualizing the real world into a 3D model and implementing optimization through real-time monitoring, simulation-based analysis, and prediction.

In water management, the digital twin provides a system where real-time monitoring of weather and hydrological observation data is conducted based on a 3D terrain map. It simulates various water management issues such as floods, droughts, and water quality in a virtual world, visualizes the results on a 3D terrain, and supports optimal decision-making through feedback. By applying such digital twin management technology, K-water aims to establish the "One System" water management platform for dams, watersheds, and rivers nationwide by 2024.

b. Challenges

As this is the first application of digital twin technology to the field of managing digital twin technology, it is necessary to establish the concept of implementing digital twin technology to suit human resource management, along with the idea of improving the utilization of practical user hubs and developing data technology that enhances the speed of processing high volumes of data.

c. Solutions

Providing monitoring functions for real-time watershed information based on 3D terrain data.
Visualizing simulation results of rainfall-runoff, dam operations, and downstream river simulations based on real-time hydrological observation and rainfall prediction data.
Analyzing and visualizing flood risks early by integrating constraints on dam operations and downstream river impacts due to dam discharge.
Incorporating real-time flood analysis and historical flood data replication into the platform.

(2) AI Water Treatment Plant

a. Description

To establish a water supply system that people can trust, 4th Industrial Revolution technologies such as artificial intelligence have been introduced into the water production and supply process. AI water treatment plants autonomously operate water production and supply processes using big data and artificial intelligence instead of human analysis and judgment. It signifies intelligent water treatment plants integrating optimal energy management, timely facility maintenance, and innovative video surveillance technology.

b. Challenges

Minimizing human errors during sudden changes in water quality or water management conditions through AI-based operation of water treatment plants to supply water more stably.

c. Solutions

Automation of water treatment processes based on big data and artificial intelligence (AI).
Energy Management System (EMS) can monitor power in real-time, analyze data, and manage equipment.
Predictive maintenance system (PMS) for real-time state-based early detection and prediction maintenance of significant facilities.
Intelligent video surveillance (AI video surveillance) is achieved through real-time video analysis, anomaly detection, sensor operation, and automatic CCTV tracking.

(3) SWNM(Smart Water Network Management)

a. Description

Water leaks occur in various forms in water pipes, and a scientific and efficient pipe network management plan is needed to reduce these leaks. SWNM technology combines IoT and AI technology in the entire tap water supply process to build and operate a predictable tap water supply system, including preemptive and active response to pipeline accidents such as leaks and water quality abnormalities.

b. Challenges

Realization of ICT and AI-based pipe network management technology to provide stable water supply and clean tap water throughout the entire tap water supply system.

c. Solutions

Establishment of block systems (DMA) for block-level facilities (flow rate, water pressure, etc.) and transmission

facilities.

Operation technology for optimal water pressure operation considering high water pressure, fluctuations, etc.

Leak detection and water loss management based on AMI.

Water quality management technology for monitoring and responding to water quality changes.

System construction for optimal network operation and decision support.

3. Detail of the Projects

3-1. Digital Twin Water Management Platform (Digital GARAM+)

(1) Description

Background to building the platform

In response to the increased complexity and uncertainty of water management due to climate change, there has been a need to overcome the limitations of existing water management systems and transition to a new water management paradigm. K-water is developing the Digital Twin Water Management Platform "Digital GARAM+" by incorporating digital twin technology into existing water management technology. Starting with the Seomjin River basin in 2021, K-water will establish the "One System" water management platform for dams, watersheds, and rivers nationwide by 2024.

Direction of Platform Construction

Digital twins, which reflect various situations expected in the real world in a virtual world and derive problems and solutions, have expanded from manufacturing to multiple fields such as transportation, urban planning, and smart city operations. In this platform, digital twin technology is applied in water management, real-time monitoring of weather and hydrological observation data within the watershed is conducted, and various water management issues such as floods, droughts, and water quality are simulated in the virtual world. Results are displayed on a 3D terrain, and optimal decision-making is supported through feedback.

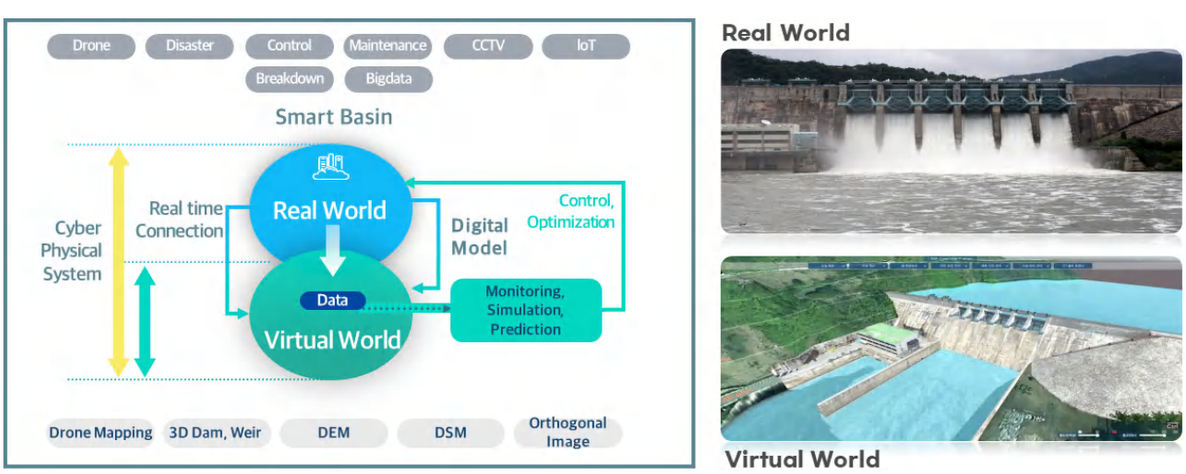


Figure 3.1 Concept of Digital Twin in Water Management

This platform comprises four water management packages, including monitoring, flood, drought, and water cycle. It allows users to intuitively understand the analysis results by visualizing simulation results in 3D on high-resolution topographic data, thereby improving water management decision-making and management. It was developed to prevent disasters. In this way, three principles are established when developing a platform and development is underway.

1) Building a platform that considers user convenience rather than developer-centric.
   To increase the platform's usability, features that water management officials frequently use and need in their actual work were implemented.

2) Ensuring speed and accuracy
   If data processing speed is slow, decision-making will be delayed, ultimately resulting in the non-use of the system. Moreover, to prevent incorrect decision-making, the platform was constructed to minimize errors between the real and virtual worlds by optimizing the system for fast operation and displaying accurate results with meaningful physical significance.

3) Ensuring future expandability and technical capabilities
   Considering that various future functions will be developed and compatible with the platform, development was pursued as an open-source Web-GIS-based platform.

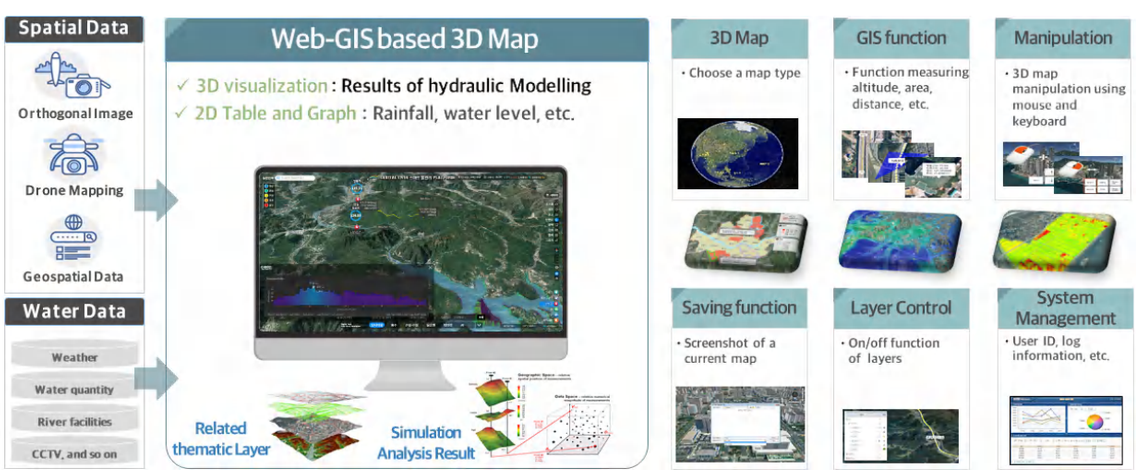


Figure 3.2 Key Functions of the Digital Twin Water Management Platform

(2) Challenges

As an initial application of digital twin technology in the watershed-level water management field, concept establishment tailored to water management characteristics and understanding the overall business process of water management personnel to enhance platform usability were required. Efforts were also made to develop data lightweight technology to load and display large volumes of data quickly, ensuring real-time interpretation of 2D flood analysis and developing an AI-based real-time flood analysis system to be installed in the future.

(3) Solutions

① Main Screen UI/UX of the Digital Twin Water Management Platform

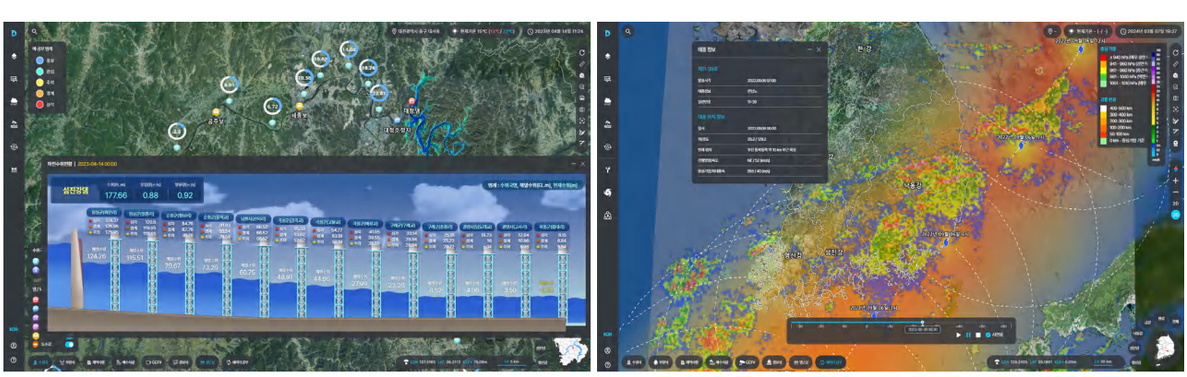
The main screen of the platform was designed so that users can intuitively use features without a manual, and functions can be displayed on the platform when users click on the desired function. Additionally, the integrated search function allows users to move to the desired location easily and quickly, and the Key Map displays only the information of the desired watershed so that it can be used.

② High-Resolution 3D Terrain Information Construction

For a digital twin to be applicable and effective in water management, it must reflect the real world as accurately as possible, with assured precision. Considering this, the platform's foundation is built upon the construction of high-resolution 3D terrain information. Initially, terrain information construction involved the application of 1m and 5m DEM (Digital Elevation Model), orthoimages, and digital terrain maps. River terrain not included in existing data was created by reflecting river cross-section information from river basic plans to produce 3D terrain data. Moreover, drones were utilized for close-range imaging of river facilities such as bridges, followed by 3D object modelling and integration into the platform to more accurately reflect spatial information from the real world. For dam reservoir areas, precise depth measurement results from multibeam echo sounders were utilized to visualize reservoir bottoms as if scanned in 3D. Such precise terrain construction of dams, rivers, and others significantly contributed to enhancing reproducibility regarding changes in water level and discharge, thereby significantly improving the accuracy and reliability of this platform.

③ Real-Time Monitoring System

This platform includes monitoring capabilities to view essential data for water management, facility status, and more. Users can access real-time rainfall radar data, typhoon trajectory information provided by the Meteorological Administration, and rainfall observation information for each region. Moreover, through integration with flood control centres and K-water's water level stations, the real-time status of dam and river water levels can be monitored. By connecting CCTV cameras, real-time on-site conditions of major dam and river locations can be observed. Additionally, constraints on dam discharge directions were investigated and integrated into the platform, allowing water management personnel to easily and quickly grasp constraint information during dam operation and support efficient and safe decision-making regarding dam discharge volumes, considering constraints imposed by relevant agencies.



(a) Real-Time Water Level Information Provision for Dams and Rivers (b) Weather Information (Typhoon, Rainfall Radar) Provision

Figure 3.3 Real-Time Monitoring Functionality

④ Water Management Analysis and Decision Support

This platform has been designed to facilitate efficient flood management decision-making by linking with the Flood Analysis System currently utilized for dam operation decision-making. Simulation results for rainfall runoff, dam operation, and downstream river simulation based on dam discharge have been visualized in the virtual world, allowing early prediction and warning of flood risks by analyzing constraints and downstream river impacts.

Additionally, this platform enables real-time flood analysis and reproduces past flood events. This allows stakeholders to review past flood events, compare and review flood risk maps and damage investigation data produced by the Ministry of Environment, and derive improvement measures for vulnerable areas. Moreover, it contributes to enhancing the flood response capabilities of management agencies during flood occurrences.

3-2. AI Water Treatment Plant

(1) Description

Global advanced countries are introducing ICT technologies such as Artificial Intelligence (AI), Big Data, and the Internet of Things (IoT) based on the Fourth Industrial Revolution to address water-related challenges stemming from climate change and demographic shifts. Particularly, AI technology has been gaining global attention and is being utilized in various industries. In Korea, the "National Strategy for Artificial Intelligence (AI)" was established in 2019, and the "Korean New Deal" was launched in 2020 to strengthen digital, green, and safety networks. Through these initiatives, efforts are being made to enhance digital transformation in industrial sectors and aim for carbon neutrality (Net-Zero). As part of the comprehensive SWM (Smart Water Management) project under the "Korean New Deal," K-water is promoting the introduction of AI-based smart water treatment plants.

The AI-based smart water treatment plant is being implemented in 43 regional water treatment plants operated by K-water. This system resolves issues inherent in conventional water treatment plants and enables eco-friendly and energy-efficient systems with improved operational management and productivity. The smart (AI) water treatment plant consists of four technologies: autonomous operation of water production processes using AI, optimal energy management (EMS, Energy Management System), predictive maintenance of facilities (PMS, Predictive Maintenance System), and intelligent visual safety management. AI trained on vast amounts of water operation big data from the past 3 to 5 years analyzes real-time data measured on-site to achieve efficient water treatment plant operation and management.

(2) Challenges

Developing standard models and integrated platforms for autonomous operation, energy management, predictive maintenance, and intelligent visual safety systems using big data and artificial intelligence to replace human analysis and decision-making in water treatment plants.

(3) Solutions

① Autonomous Operation of Water Treatment Processes

An AI autonomous operation algorithm based on big data was developed and implemented for eight water treatment processes' major operational factors (production volume, water quality), enabling real-time decision-making for water treatment processes.

K-water Smart AI Water Treatment Plant

"A smart water treatment plant that integrates autonomous operation, energy management, predictive maintenance, and intelligent safety management using big data and AI, replacing human analysis and decision-making in water treatment plant operation."

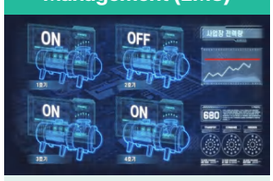
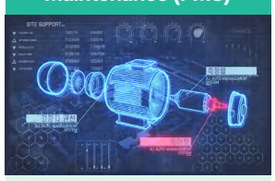
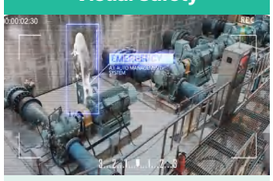
Autonomous Operation	Energy Management (EMS)	Predictive Maintenance (PMS)	Intelligent Visual Safety
			
AI Analysis and Prediction, Operation	Power Consumption Reduction through Optimal Equipment Operation	Preventive Maintenance Based on Equipment Status	Accident Prevention through Real-Time Video Analysis

Figure 3.4 AI Water Treatment Plant Overview

② Smart EMS (Energy Management System)

A system capable of real-time power consumption monitoring, data analysis, and equipment management using AI was implemented for equipment with high energy consumption.

- (Pump Control) Optimal pump control utilizing minimum required pressure for reservoirs
- (Power Peak) Alarm generation when predicted power demand exceeds target peak value

③ Smart PMS (Predictive Maintenance System)

Smart PMS enables real-time condition-based predictive maintenance for major facilities.

- (Autonomous Diagnosis) Real-time acquisition and analysis of pump motor vibration data for fault detection and cause identification

  * Fault items: misalignment, mass imbalance, impeller defects, motor defects, bearing defects, cavitation

④ Intelligent Video monitoring

The technology enables real-time video analysis alerts and automatic CCTV tracking on existing CCTV and detection sensors.

- (AI video monitoring) AI video analysis alerts, such as facilities and security accidents, industrial safety, etc., considering the impact of accidents.

  * (Facility accident) Fire, leakage of pipes/ (facility security) intrusion, wandering/ (industrial safety) collapse, rescue signal, electic shock, not wearing a safety helmet

- (Automatic tracking) When a detection sensor alarm occurs, the camera is rotated(enlarged) so that workers can immediately check for abnormalities(actual conditions or malfunctions)

3-3. SWNM (Smart Water Network Management)

(1) Description

SWNM Concept

Tap water is supplied to consumers through pipes buried underground. However, as time passes, water leakage

accidents due to aging and water contamination due to corrosion continue to occur. Therefore, many countries are making great efforts, such as technology development, to manage and prevent them effectively.

Most water supply facilities are buried underground, making inspection and observation are challenging. Therefore, efficient management of these facilities is difficult. Thus, efforts are being made to enhance related equipment and device technologies and supply stable tap water supply through system automation.

K-water has introduced the super-gap technology, SWNM in the field of local water supply, building upon the outstanding results and advanced technologies achieved through the Local Water Supply Efficiency Enhancement Project initiated in 2004, and the Modernization Project implemented since 2017 to improve and enhance water supply operations and management.

SWNM integrates digital-based IoT and AI technologies into the tap water supply process to enables proactive and responsive measures such as leak detection and water quality anomaly detection, aiming to build and operate a tap water supply system that can flexibly adapt to rapidly changing environments. This represents a new paradigm in the water industry, optimizing water management through proactive and responsive approaches.

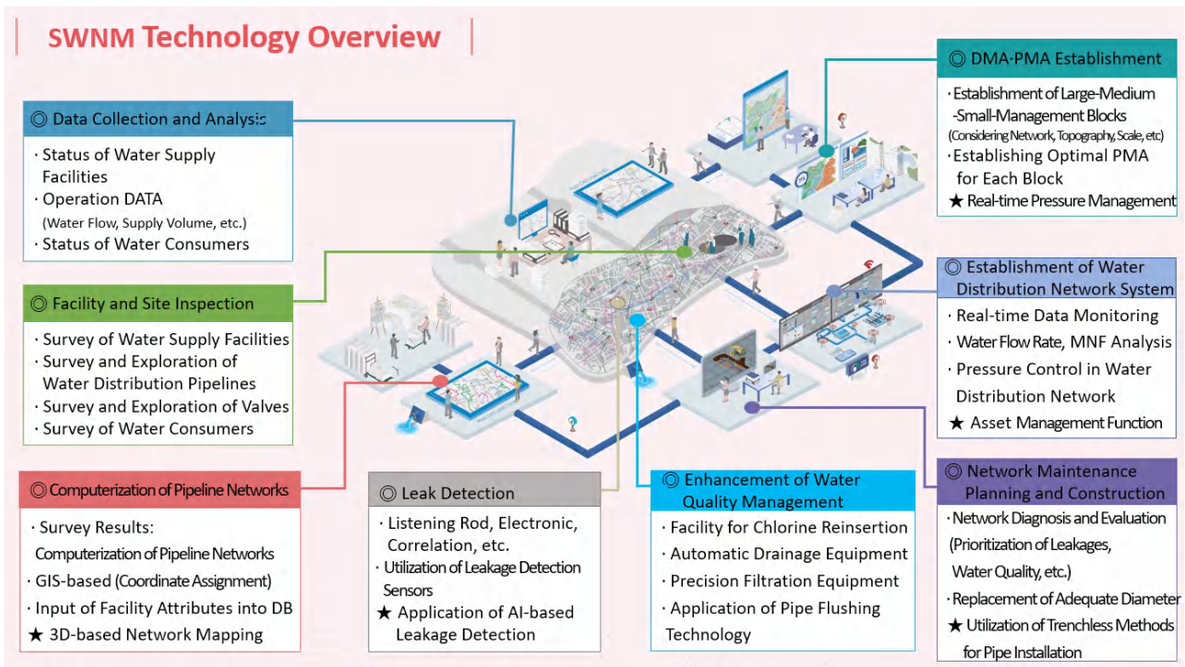


Figure 3.5 Outline of SWNM

(2) Challenges

By reducing leakage and accidents through the scientific development/ efficiency of water pipe facilities, production costs are reduced and high- quality water supply services are realized.

(3) Solutions

① Investigation / Analysis

Accurate investigation of pipeline conditions through on-site inspection of current status data of water supply facilities ect., Used as basic data for applying K-water's core operation and management technology.

- Computerization of pipeline network
- Analysis of water pressure and flow rate
- DMA Planning and isolation confirmation
- Analysis of water supply efficiency by DMA

② Water leakage management

MNF(Minimum Night Flow) Analysis by DMA, leakage volume analysis through real-time data analysis based on AMI.

- MNF(Minimum Night Flow) Monitoring, Analysis
- Real time monitoring usage of AMI and analysis of supply volume
- Leak detection and Recovery

③ DMA Establishment

Through the installation of equipment for transmitting operational data from block inlet facilities(Flowmeter, hydraulic management facility etc), the operation status of the block is monitored, and install additional facilities(Emergency connection pipes, automatic drains etc) to enable systematic management of related facilities.

- Small block (DMA) Construction
- Mangement block construction and Water quality monitoring
- Advancement of accident response

④ Hydraulic pressure management

Operation of decompression valves and pumps to analyze the flow rate and water pressure data by DMA and to manage the area with high or large deviation with appropriate water pressure

- PMA Establishment and Operation
- Simple Hydraulic pressure management(decompression, pressurization)
- Multistage reduction, flow rate control, pressure pump operation in parallel
- Real-time hydraulic management(AI autonomous operation)

⑤ Pipeline maintenance

By analyzing the performance of the pipeline facility through diagnosing and evaluating the condition of the pipes, the problematic sections and old pipes are accurately identified.

Various technologies are then applied to analyze the old pipes, enabling efficient pipeline maintenance to be performed accurately.

- Operation data Analysis
- Diagnosis of old pipes based on actual measurement (excavation, specimen collection, and jurisdiction)
- Prediction of the old age pipe based on the asset management system
- Minimize inconvenience such as civil complaints using non-excavation methods, etc

⑥ System Establishment

Provide various information, such as real-time monitoring, alarm support, and optimal energy management for the efficient operation management of water facilities, and support network operation management that enables facility operation DB analysis, diagnosis, and evaluation using IT-based systems for optimal operation.

- Standard water operating system(i-water, SCADA)

- Local Water Supply Integrated Information System (Water-INFOS)
- Water pipeline diagnostics·operation system (Water-NET)

  * Water flow rate analysis, accident response simulation, and pipeline maintenance section selection, etc.

⑦ Water quality management

Ensure optimal water quality by maintaining stable water quality and efficient operation by preventing the spread of accidents through real-time water quality monitoring of the supply system and rapid response to crises, responding to immediate water quality changes, and preventing accidents through preemptive measures.

- Real-time Water Quality Instrument
- Automatic operation such as automatic drain, pipe cleaning infrastructure
- Water quality stabilization through the use of precision filtration devices and re-chlorine input.

4. Future Plan

To respond to water problems caused by the extreme climate crisis, K-water succeeded in transforming the K-water digital water management system that can react preemptively to water problems through digital water management transformation on based on the 4th industrial revolution technology.

The Digital Twin Water Management Platform is currently being promoted in cooperation with the Saudi government as part of the Digital Twin Project.

The AI Water Purification Plant has received the Global Lighthouse Network Award. This recognition stems from the World Economic Forum, held in Davos, Switzerland, acknowledging the achievements of introducing the AI operating system in preparation for the volatility of water supply due to climate change.

SWNM has demonstrated many achievements, actively conducting business domestically and internationally.

K-water aims to establish a digital water management paradigm and become a global water company that leads the response to the climate crisis through the digital transformation of water management.

Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

North and Central Asia

Kazakhstan

Kazvodkhoz RSE

1. Introduction

(1) Water Resources of Kazakhstan

Kazakhstan, positioned at the heart of Central Asia, grapples with complex water management challenges shaped by its expansive geographical diversity and stark climatic variations. Historically, the region's approach to water resources during the Soviet era, characterized by grandiose but ecologically short-sighted irrigation projects, notably contributed to the Aral Sea's catastrophic shrinkage, transforming it into a symbol of environmental mismanagement. This historical backdrop frames the current national efforts to rehabilitate and conserve water resources efficiently.

Today, Kazakhstan's water management confronts several critical issues. The country's geography, featuring vast semi-arid and arid zones, contributes to uneven distribution of water resources, with the northern and eastern regions relatively water-rich compared to the parched south and southwest. Aging water infrastructure, much of it a legacy of the past century, is inefficient and leaky, necessitating comprehensive modernization to meet current and future demands.

Water quality is another pressing concern, with pollution from agricultural runoff, industrial discharges, and inadequate urban wastewater treatment compromising river and groundwater quality. This pollution not only poses health risks but also impacts biodiversity and ecosystem services. Climate change further exacerbates these challenges, with predictions pointing towards heightened water scarcity threats, altering precipitation patterns, and the increased frequency of droughts which could severely impact agricultural productivity and water availability.

The Kazakh government has recognized these challenges, embarking on a multifaceted strategy for water resource management. Legislative and policy frameworks have been put in place to promote sustainable water use, emphasizing conservation, efficiency, and quality. International cooperation plays a pivotal role, as Kazakhstan shares several significant rivers with neighboring countries; thus, transboundary water management agreements are crucial for ensuring fair and sustainable water distribution.

Efforts to modernize irrigation practices and upgrade water infrastructure are underway, focusing on adopting cutting-edge technologies and methodologies to enhance water use efficiency. This is particularly significant in the agricultural sector, the largest consumer of water, where traditional practices have often led to wasteful water use. Projects aimed at mitigating pollution and restoring ecosystems are also part of the national water management strategy, seeking not only to improve water quality but also to rehabilitate environments affected by pollution and overuse.

Environmental restoration initiatives, such as those targeting the Aral Sea and Lake Balkhash, symbolize a commitment to rectifying historical damages and safeguarding natural assets for future generations. These efforts are accompanied by educational campaigns designed to raise public awareness about water conservation and foster a culture of sustainable water use among citizens.

Looking forward, Kazakhstan's path to sustainable water management is fraught with challenges but also buoyed by opportunities for innovation and cooperation. The country stands at a crossroads, with the necessity to balance economic development and environmental sustainability driving its approach to water resource governance. The journey towards a secure water future is complex, requiring continued commitment,

investment, and international collaboration to ensure that water, an invaluable resource, is preserved and wisely managed for the prosperity of Kazakhstan and its people.

(2) Kazvodkhoz RSE

The Kazvodkhoz RSE operates under the Water Management Committee of the Ministry of Water Resources and Irrigation of the Republic of Kazakhstan, playing an essential role in the nation's water resource management. This entity is fundamental in ensuring the equitable allocation of water across various sectors such as agriculture, industry, and residential use. It oversees the construction, operation, and maintenance of key water infrastructure, including dams, reservoirs, and irrigation systems, crucial for water storage, supply, and flood control.

Kazvodkhoz RSE also takes active measures to safeguard water quality, aiming to prevent pollution and protect aquatic ecosystems, ensuring that water remains safe for consumption and use. Environmental conservation efforts are pursued to restore and protect water bodies and their surroundings, addressing the lingering effects of past mismanagement practices like the desiccation of the Aral Sea.

International cooperation is another critical area, with Kazvodkhoz RSE involved in negotiations and agreements regarding the shared management of transboundary water resources. The organization supports research and innovation in water management techniques and technologies, adapting to Kazakhstan's unique challenges in water scarcity and distribution. Public awareness campaigns and education initiatives are crucial components of its strategy, promoting sustainable water use among citizens and stakeholders. Kazvodkhoz RSE's activities reflect Kazakhstan's broader commitment to achieving sustainable water resource management, balancing the nation's economic development with environmental stewardship. The ongoing adaptation and effectiveness of such entities are vital for Kazakhstan's future sustainability and ecological health, given the complex challenges of managing water in a changing climate.

2. Selected Completed Projects

(1) Masterplan of Kamensky SWM (Smart Water Management) Project

a. Description

Smart Water Management Project aims to reduce the production cost and supply well treated drinking water by minimizing water losses and accidents through scientific operation and management of water supply system.

The government of Kazahstan tried to reduce Non-Revenue Water (NRW) through installing real-time water flow and pressure monitoring system based on ICT. It also sets up the plans including replacement of aged pipes in water supply system to improve operational efficiency.

b. Challenges

Challenges related to Non-Revenue Water (NRW) and water management in Kazakhstan include aging infrastructure leading to physical losses, inaccurate metering systems affecting billing accuracy, water scarcity exacerbating resource management issues, poor data management hindering decision-making, and regulatory framework challenges impacting water management practices. To address these issues, Kazakhstan may need

to invest in infrastructure upgrades, modernize metering systems, implement efficient water resource planning strategies, improve data monitoring and management practices, and strengthen regulatory enforcement to enhance water management efficiency and reduce NRW levels.

c. Solutions

Potential solutions to tackle Non-Revenue Water (NRW) and enhance water management in Kazakhstan may include: 1) Infrastructure upgrades: Investing in repairing and modernizing aging water distribution networks to reduce physical losses from leaks and pipe bursts. 2) Implementing advanced metering technologies: Upgrading metering systems to improve accuracy in measuring water consumption and billing, thus reducing commercial losses. 3) Data-driven approaches: Enhancing monitoring systems and data management practices to identify sources of NRW and make informed decisions for effective water resource management. 4) Stakeholder engagement: Collaborating with water utility companies, government agencies, and local communities to raise awareness, promote water conservation practices, and address unauthorized consumption issues. 5) Policy reforms: Strengthening regulatory frameworks, establishing clear guidelines, and enforcing compliance measures to ensure efficient water management practices and reduce NRW levels sustainably in Kazakhstan.

3. Detail of the "Masterplan of Kamensky SWM Project"

(1) Context

In Kamensky, Kazakhstan, the water management system faces multiple challenges requiring comprehensive and innovative solutions. One of the most pressing issues is the age of the manhole infrastructure, which is deteriorating, often leading to flooding and potential water contamination during rainy conditions. These old manholes compromise the efficiency and reliability of the water distribution network, highlighting a critical need for updates or replacements.

Faulty connectors between management and private manholes present a significant risk by causing water leaks. These leaks not only waste valuable water resources but can also lead to contamination, posing a health risk to the community. The extreme climate conditions of the region, including harsh winters and rainy seasons, add to the complexity by hampering manual water meter readings, thereby affecting billing accuracy and water allocation efficiency.

There's also the broad challenge of transitioning from manual to smart metering systems; this shift, while beneficial, requires substantial investment and faces potential resistance from both the local populace and institutional structures. The initial costs associated with installing smart meters and integrating advanced monitoring systems are considerable, yet necessary for long-term sustainability and efficiency.

Despite these hurdles, addressing water leaks through technological upgrades is crucial for conservation and ensuring a clean water supply. The collection and accurate analysis of water usage data from smart meters can dramatically improve operation management, leak detection, and customer billing processes. Engaging the community and stakeholders in understanding the benefits of smart water management technologies is essential for overcoming resistance to change.

Resource management poses an ongoing challenge, especially with the demand for water increasing alongside

the need to minimize losses through leaks and unaccounted-for water. Kamensky's water management efforts must therefore focus on modernizing infrastructure, leveraging technology for efficient resource allocation, and fostering community involvement.

Successfully tackling these challenges requires a multifaceted strategy that combines technological advancement, infrastructure improvement, and active stakeholder engagement. By focusing on these areas, Kamensky can move toward a more efficient, sustainable, and resilient water management system.

Figure 3.1 Chlorine injection facilities in Kamensky, Kazahstan

Figure 3.2 In-line pumping facilities in Kamensky, Kazahstan

Figure 3.3 Valve boxes in Kamensky, Kazahstan

(2) Methodology

Establishing smart water management in Kamensky, Kazakhstan, involves a strategic approach to overcome existing challenges and leverage modern technology to ensure efficient water use and distribution. The first step is upgrading the aging manhole and pipe infrastructure to prevent water loss and ensure system integrity. This involves replacing deteriorated structures and using durable materials to withstand environmental pressures.

Introducing smart meters is essential for real-time water use monitoring, allowing for accurate billing and identifying unusual water usage patterns indicative of leaks. The installation of these meters requires a systematic approach, prioritizing areas with the highest rates of water loss or inaccuracies in billing. Training local technicians on the installation and maintenance of smart meters ensures long-term sustainability.

To address faulty connectors and reduce leakage, a comprehensive survey of the existing network should be conducted. This involves identifying weak points and employing advanced sealing technologies that can withstand the specific climatic conditions of Kamensky. Engaging with technology providers for custom solutions tailored to the region's needs can enhance system resilience.

Adopting an Advanced Metering Infrastructure (AMI) system facilitates the remote reading of meters, significantly reducing the labor costs and inaccuracies associated with manual readings. This system also supports the implementation of a dynamic billing system, potentially encouraging water conservation among consumers.

Implementing a district metering area (DMA) approach allows for the detailed monitoring of water flow and pressure within different segments of the network. This strategy aids in pinpointing leaks and understanding water use patterns, which is essential for effective water distribution and conservation strategies.

Establishing an integrated operations center is crucial for collating and analyzing data from smart meters, flow meters, and pressure sensors. This center serves as the command hub for managing the water network, employing predictive analytics to optimize water distribution and anticipate system maintenance needs.

Collaboration with local communities and stakeholders is essential to ensure the successful adoption of smart water management practices. This includes educational campaigns on the importance of water conservation and how residents can contribute to the sustainability of their water supply. Economic analysis and securing funding are vital for the project's implementation. This could involve exploring public-private partnerships, government grants, or international aid to offset the initial investment costs. Transparency in the economic benefits, including long-term savings and environmental impacts, encourages stakeholder buy-in.

Finally, continuous monitoring and adaptation are key to addressing emergent challenges and incorporating new technologies. This approach ensures the smart water management system remains effective and responsive to the evolving needs of Kamensky and its residents. By systematically addressing these areas, Kamensky can establish a smart water management system that ensures efficient, sustainable, and equitable water distribution, setting a benchmark for similar initiatives in the region.

(3) Detail plan of the Smart Water Management

Detailed plan for improving water management in the Kamensky region of Kazakhstan through the implementation of a smart water management master plan offers a comprehensive approach to addressing critical water supply challenges. The integration of smart meters, flow monitoring systems, water pressure monitoring systems, and water quality monitoring alongside the development of an integrated operations center

is a strategic move towards enhancing water efficiency, quality, and distribution. Here are some thoughts and potential strategies to consider based on your outline:

Smart Meter Implementation

The transition from manual to smart meter readings addresses the logistical challenges posed by climate and terrain, as well as the inefficiencies in manpower. This shift not only provides real-time data for more efficient water use and billing but also significantly improves leak detection, allowing for timely interventions. Emphasizing customer engagement and education on the benefits of smart metering (such as potential savings and conservation) can facilitate smoother adoption and acceptance.

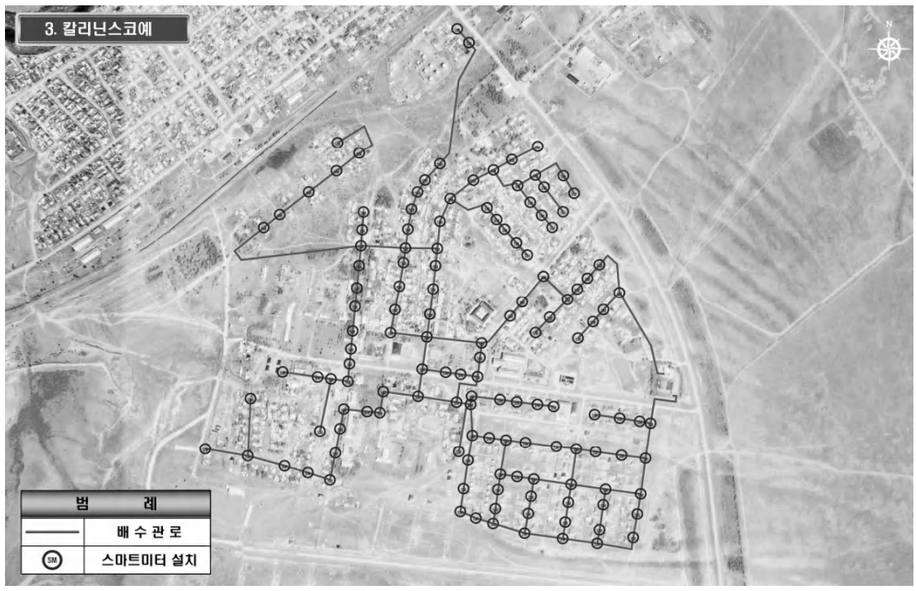


Figure 3.4 Planned location of smart meters in Kamensky(Village 3), Kazahstan

Figure 3.5 Planned location of smart meters in Kamensky(Village 14), Kazahstan

Flow Monitoring System

Your criteria for selecting flow meters—focusing on battery life, suitability for the DMA's conditions, and compliance with Kazakhstan's regulations—lay a strong foundation for accurate water flow monitoring. Ensuring that these tools are scalable and adaptable to future water network expansions or upgrades is essential. Collaborating with technology providers to tailor solutions to the unique needs of the Kamensky region could enhance system efficiency.

Water Pressure Monitoring System

The selection criteria for water pressure gauges, aimed at detecting supply conditions, poor discharge, and leaks, are critical for maintaining an optimal water supply network. Integrating these systems with mobile and web applications could enable more dynamic, real-time remote monitoring and quicker response times to anomalies.

Water Quality Monitoring System

Choosing online water quality monitoring instruments focusing on critical quality parameters ensures the safety of the water supply. Continuous monitoring can help in promptly addressing quality issues, safeguarding public health, and meeting regulatory standards. Engaging with community stakeholders on water quality goals and findings can enhance transparency and public trust.

Integrated Operation Center

Positioning the integrated operation center within the existing Kamensky office space is a strategic use of resources. However, ensuring that this center is equipped with advanced data analytics and visualization tools is paramount for the effective management of the smart water management systems. Training and capacity building for the staff operating this center will be crucial for the success of the integrated system.

Figure 3.6 Plan of the Integrated Operation Center

Investment Plan and Economic Analysis

Your detailed investment plan and economic analysis demonstrate a thorough understanding of the scope and scale of this initiative. Highlighting the anticipated improvements in water flow and leakage reductions can make

a strong case for the economic viability of the project. Engaging with potential investors or funding agencies early on, presenting the benefits not just in terms of cost savings but also environmental and social impacts, might secure the necessary financial backing.

Addressing Challenges

The issues of manhole aging and faulty connectors present significant risks to the integrity of the water supply system. Innovative solutions, such as waterproofing technologies for manholes and improved materials or techniques for pipe connections, could be explored. Engaging with local communities to identify and address these challenges can foster a sense of ownership and responsibility for the water system's success.
Comprehensive approach sets a strong foundation for transforming water management in the Kamensky region. Continuing to adapt and refine your strategies in response to technological advancements and community feedback will be key to the long-term sustainability and success of this smart water management initiative project.

4. Future Plan

Kamensky's future plan for water management is centered around fully integrating smart water technologies to optimize water distribution, reduce waste, and improve water quality for its residents. The region aims to replace aging infrastructure with modern, durable materials and technologies, ensuring the resilience of the water supply system against environmental and operational challenges. There will be a focus on expanding the use of smart meters and remote monitoring systems to provide real-time data analysis, facilitating proactive maintenance and efficient resource management. Kamensky plans to engage the community and stakeholders through educational programs and initiatives, highlighting the importance of water conservation and the benefits of the upgraded water management system. Lastly, the region is committed to exploring sustainable funding models and partnerships to support the ongoing adoption of advanced water management technologies, paving the way for a more secure water future.

5. References

Report of Masterplan of Kamensky SWM Project, Kazahstan (2023)

Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

North and Central Asia

Kyrgyzstan

Water Resources Service of
the Kyrgyz Republic

1. Introduction

(1) Kyrqyzstan

Kyrgyzstan is a landlocked republic in Central Asia, with its capital in Bishkek. It shares borders with Uzbekistan, Tajikistan, Kazakhstan, and China, and much of its territory is characterized by mountainous terrain, earning it the nickname "the Switzerland of Central Asia."

Approximately 40% of the country's landmass consists of mountainous regions exceeding 3000 meters above sea level. Stretching from east to west, the Tien Shan mountain range runs along its border with China. To the south lies Tajikistan, encompassing the Pamir Plateau.

The country's major river is the Naryn, a tributary of the Syr Darya River, and its primary lake is Issyk-Kul, located in the northeastern part of the country. Issyk-Kul Lake spans approximately 180km east to west, 60km north to south, with a circumference of 700km. Situated at an elevation of 1600m above sea level, it has a unique hydrological system separate from the Naryn River. Issyk-Kul Lake is the 24th largest lake in the world by surface area, covering 6200km^2, and the 10th largest by volume. With an average depth of 279m and a maximum depth of 702m, it ranks as the 7th deepest lake globally. Despite being fed by over 50 tributaries, it has no outflowing rivers.

Unlike neighboring countries like Kazakhstan and China, Kyrgyzstan lacks deserts within its borders, benefiting from a favorable climate. The valley regions, extending east to west, are suitable for human habitation and fall under the Köppen climate classification of a Mediterranean-influenced continental climate (Cs), akin to climates in Rome, Italy, or San Francisco, USA. Mountainous areas exhibit a humid continental climate (Df), with higher elevations experiencing a cold mountain climate (H). To the south, along the Tien Shan range, and to the north, along the border with Kazakhstan, steppe (BS) and desert (BW) climates prevail.

When comparing the actual precipitation, Kashgar, a Xinjiang Uyghur autonomous region of the People's Republic of China located 100 km south of the Tianshan Mountains, has annual precipitation of 60 mm, but Vishkek (43 degrees north latitude, 800 m above sea level) has 450 mm of precipitation. This is similar to Rome or San Francisco. The average temperature in Vishkek is -3 degrees in January and 25 degrees in July.

The following sections provide detailed information about Kyrgyzstan's water resources, including how water resource management is conducted, ongoing initiatives, and future prospects.

(2) Water Resources of Kyrqyzstan

Kyrgyzstan, situated in Central Asia, considers its internally formed water resources as crucial assets. The country boasts significant hydro and water resources, a cornerstone of its economy. With a hydroelectric potential of approximately 174 billion kWh and a capacity of 19.8 million kW, its water resources are primarily concentrated in the storage capacity of about 76 billion cubic meters across 6580 glaciers.

From a hydrological perspective, Kyrgyzstan's territory is divided into two main regions: collection and dispersion. The country's water usage structure reveals that around 90% of water is used for irrigated agriculture, industry accounts for about 6%, and less than 3% is allocated for urban water supply. Other sectors like forestry, fisheries, energy, and services collectively consume up to 1% of domestic water usage.

Kyrgyzstan boasts over 2000 rivers spanning more than 10 km in length, totaling nearly 35,000 km. Lakes, reservoirs, and ponds cover a combined area of 6836 square kilometers, predominantly at 3-4 thousand meters

above sea level.

Water resource management stands as a pivotal policy for the Kyrgyzstan government, overseen by the Department of Water Resources Service. This department is dedicated to efficiently managing and protecting national water resources, offering various services to meet diverse user demands. Additionally, it performs regulatory functions such as licensing, tariff setting, and monitoring compliance with water laws, while also providing services like water supply organization and irrigation infrastructure maintenance.

Overall, Kyrgyzstan's water resources play a crucial role in its economic development, energy security, environmental conservation, and maintaining a sustainable water balance.

2. Selected Completed Projects

(1) Feasibility study of Hydropower Development Project in Krygyzstan

Description

The project, driven by the "Overseas Plant Feasibility Study Project Agreement" between K-water, the Korea Plant Industries Association, and POSCO Engineering & Construction, aimed to conduct on-site surveys and feasibility studies for investment projects in hydropower development target sites. The initiative was undertaken to advance investment projects in hydropower development target sites by conducting on-site surveys and feasibility studies in response to local national circumstances. However, due to disruptions caused by local political events, changes in local conditions, and the transfer of project rights, feasibility studies were conducted for only two final target sites through on-site investigations.

Project Contents

<table>
<tr><th>Category</th><th>Naryn</th><th>Kiropksi</th><th>Oroto-tokoy</th><th>Kemin</th><th>At-Bashi</th></tr>
<tr><td>Outline</td><td>New dam</td><td>Exsiting dam</td><td>Exsiting dam</td><td>New dam</td><td>Exsiting dam</td></tr>
<tr><td>Location</td><td>6-hours distance from Bishkek</td><td rowspan="4">November 5th a MOU has been signed with a Kazakhstan private corporation</td><td rowspan="4">November 10th The European Bank for Reconstruction and Development will conduct a feasibility study

By the end of November the investment project will be announced for bidding</td><td>110km distance from Bishkek</td><td rowspan="4">As of November 10, the presentation by the Ministry of Agriculture took place</td></tr>
<tr><td>Site Condition</td><td>Terrain favorable Accessibility, Construction condition highly unfavorable, no compensation needed.</td><td>The terrain and accessibility are favorable, with advantageous construction conditions, and no compensation is required</td></tr>
<tr><td>Hydrological Conditions</td><td>Average wind speed of 43m³/s year round, with concern for icing during winter season.</td><td>Average wind speed of 23.9m³/s year round,</td></tr>
<tr><td>Power generation Plan Conditions</td><td>50m Elevation Drop</td><td>70m Elevation Drop</td></tr>
<tr><td>Selection</td><td>X</td><td>X</td><td>X</td><td>O</td><td>O</td></tr>
</table>

Considering the location, conditions, hydrological conditions, and development planning conditions, the target point was selected as Kemin and At Bashi.

Category	Kemin(New dam)	At-bashi(Existing dam)
Location	The point 6.9km upstream from the confluence of the Chu and Kemin rivers	The point 1.1km downstream from the existing At-bashi dam
Development Direction	Hydropower Generation	Hydropower Generation, Irrigation water

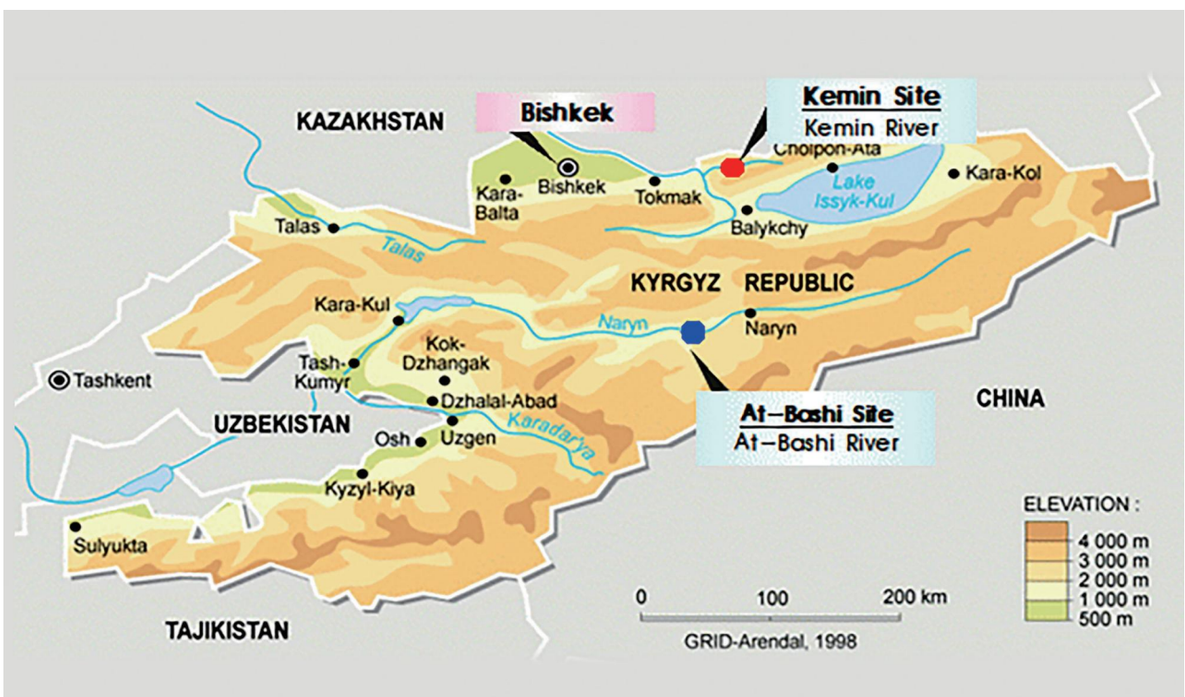
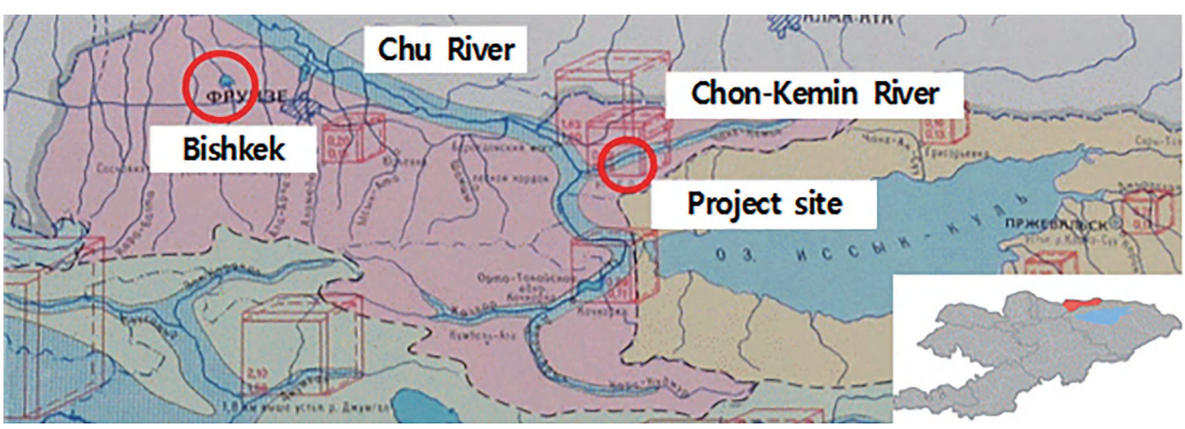


Figure 2.1 Development plan by site

(1) Kemin Hydropower Development



Classification		Dam site 1	Dam site 2
Watershed	Dam location	Confluence point of Chu river 6.9km upstream	Confluence point of Chu river 0.2km downstream
	Watershed area(km^2)	1,775	30,900
	Annual average inflow ($10^6m^3/s$)	746	1,628
Reservoir	Design flood level(m)	EL. 1,386m (Water channel Type)	EL.1,303m
	Normal water level(m)		EL.1,300m
	Low water level (m)	EL. 1,380m	EL.1,291m
Tunnel	Extension (km)	4.1	0.8~1.0
Dam	Dam spillway (m)	EL. 1,389m	EL. 1,307m
	Dam length (m)	94	60
	Dam height (m)	19	45
	Dam type	CGD	CGD
Power Plant	Power generation method	Water channel Type	Dam- Water channel Type
	Average Elevation drop (m)	65m	35m
Selection		O	

Figure 2.2 Location of each site

Figure 2.3 Kemin Dam candidate site view

An optimal hydropower development plan was established using the annual discharge of the Kemin River basin, and two sites were selected through upstream inspections and on-site surveys of the Kemin and Chu River basins. Additionally, feasibility studies were conducted for sites deemed optimal for development based on hydraulic characteristics, constructability, topographical and geological conditions, and watershed characteristics.

Item	Dry stream flow(Q275)	Low stream flow(Q355)	Normal steam flow(Q185)	Abundant stream flow(Q95)
Flow(m^3/s)	9.2	10.6	15.4	34.2

Using data on the annual discharge of the Kemin River from 1988 to 2005, sulfur analysis was conducted using the parallel method. The minimum river maintenance flow was found to be 6.4 m^3/s (Q355 minimum), and the flood discharge was estimated to be 141 m^3/s (1,000-year frequency)/

Case	1	2	3	4	5	6	7
Utilization amount(m^3/s)	15.5	16.5	17.7	18.8	21.5	25	30
Development amount(m^3/s)	8.8	9.4	10.2	10.8	12.4	14.4	17.2
Annual Development amount(m^3/s)	53.95	55.84	58.07	59.55	63.40	67.28	70.82

By determining the generation capacity for 7 cases representing 30-50% excess probability on the sulfur curve, the optimal development scale was decided. The utilized flow rate was set at 17.7 m^3/s, effective head was 66.3 m, the installed capacity was 10.2 MW, and the annual generation was estimated at 58.07 GWh.

Table 2.1 Overview of facilities

Watershed area	:	1,775km^2 (Annual average inflow)
Dam	:	Height / Length : 19m / 94m Dam spillway : EL. 1,389m (Weir: 1,386m) Dam type : Concrete Gravity Dam Total reservoir capacity : 326,000 m^3
Tunnel	:	Concrete lining tunnel(L=4.13km, D=3.5m)
Installed Capacity	:	10MW (Fransis 5.0MW × 2), Effective head 66.3m
Annual power generation	:	58.1GWh/ yr
Total Project cost	:	41million USD (Construction cost: 29million USD, etc 12million USD)

(2) At- bashi hydrological Development Project

A feasibility study was conducted based on the utilization of the existing At-Bashi Dam discharge, as proposed by the Kyrgyzstan government. The study aimed to assess the feasibility of simultaneously developing additional irrigation water supply and hydropower generation through the installation of new weirs and irrigation canals.
The specifications of the existing dam include a height of 79 meters, a length of 55 meters, and it is of the Earthfill Dam type. The power generation facilities comprise four Francis turbines with a capacity of 10 MW each. The operational method involves the installation of spillways with bottom outlets within the reservoir, operating as a controlled overflow system, which releases excess water into the At-Bashi River when the water level exceeds a certain threshold.

Figure 2.4 Upstream of At-Bashi Dam

Figure 2.5 Downstream of At-Bashi Dam

The discharge for power generation is 70 m^3/s, while gate discharge is 150 m^3/s, resulting in a total design discharge of 220 m^3/s.

The hydroelectric development scale was reviewed for sites deemed optimal for development considering favorable hydraulic characteristics, constructability, topographical features, and other relevant factors.

Classification	Point 1	Point 2
Location	Downstream 1.1km point of At-bashi Dam power plant	Downstream 1.7km point of At-bashi Dam power plant
Feature	The upper and lower channel configuration in an S shape is advantageous for water diversion. Barrage length is relatively longer compared to Point 2 The existing riverbed slope is high, leading to excessive sedimentation and increased construction costs for embankment reinforcement. Due to the high riverbed elevation and significant difference in elevation between the end of the channel and the tunnel outlet, the flow velocity inside the channel and tunnel is maintained at 1 to 1.5 m/s.	Presence of bridges and roads creates disadvantages for water diversion. The length is relatively shorter compared to Option 1 (L=70m), resulting in relatively lower construction costs. Barrage length is low, resulting in less excavation volume. Due to the low elevation difference between the riverbed and the end of the channel, the flow velocity inside the channel and tunnel is slow, at 1m/s or less. At approximately 100m downstream from the weir, there is a bridge structure, raising concerns about erosion damage to the bridge substructure.
Selection	O	

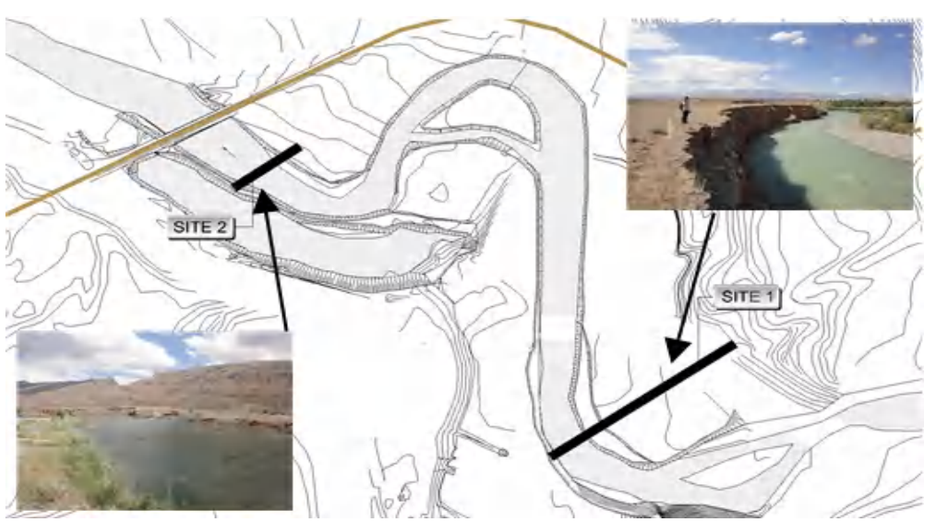


Figure 2.6 Location of barrage Candidate Spot

Hydrological Analysis

Item	Dry Streamflow(Q355)	Low Streamflow(Q275)	Normal Streamflow(Q185)	Abundant Streamflow(Q95)
Discharge	18.02	22.53	32.21	41.95

Only operational performance data for 2009 and 2011 were available, so the average values for these two years were applied to estimate the inflow volume for the planned site. Power generation calculations were conducted for 8 cases based on At-Bashi Dam discharge performance ranging from 20 to 70 m^3/s. The optimal development scale was determined with a utilization flow rate of 35 m^3/s, effective head of 20 m, installed capacity of 5.9 MW, and an annual generation of 38.38 GWh.

Development plan

Case	1	2	3	4	5	6	7	8
Utilization Quantity	20	30	35	40	45	50	60	70
Development Quantity(MW)	3.5	5.1	5.9	6.7	7.4	8.1	9.3	10.2
Annual Development Quantity(GWh)	27.81	35.89	38.38	39.56	40.22	40.87	41.78	42.25

Power generation calculations were performed for 8 cases based on the discharge performance of the At-Bashi Dam, ranging from 20 to 70 m^3/s. The optimal development scale was determined with a utilization flow rate of 35 m^3/s, an effective head of 20 m, an installed capacity of 5.9 MW, and an annual generation of 38.38 GWh.

Table 2.2 Overview of facilities

Watershed area	:	1,775km^2 (Annual average discharge)
River bank	:	Height / Length : 6m / 220m Dam spillway : EL. 1,835m (Weir: 1,833m) Dam type : Concrete Gravity Dam + Earthfill dam
Tunnel	:	Channel : L=5.66km, 5.0 × 5.0m Tunnel : L=830m, D=5.0m
Installed Capacity	:	6.0MW (3.0MW × 2), Effective head 20.0m
Annual power generation	:	38.4GWh/ yr
Total Project cost	:	73million USD (Construction cost: 51million USD, etc 22million USD)

Solution

In the detailed design phase, such as measurement and site investigations, additional on-site investigations and reviews are deemed necessary. It is especially necessary to continuously manage and secure data on aspects such as hydraulic analysis and power generation estimation to correct and improve the inflow rate.

Regarding compensation investigations, although separate investigation contracts were not conducted through local government consultation and on-site examinations, reassessment may be necessary when developing detailed plans in the future. Property reassessment is required through additional investigations of detailed items such as major construction unit costs.

The economic and financial viability of the Kemin hydroelectric project has been evaluated under the conditions of a tariff of 8 cents/kWh, a 50-year operating period, a discount rate of 12%, and an inflation rate of 8.5%,

confirming its feasibility.

The economic evaluation of the Kemin hydroelectric project indicates that under the conditions of a tariff of 8 cents/kWh, a 50-year operating period, a discount rate of 12%, and an inflation rate of 8.5%, the economic and financial viability of the project is deemed secure. Considering that the viability of the project is secured when only the power generation project is separated, it is proposed to separate the irrigation project from the power generation project to ensure the project's feasibility, with the irrigation project implemented as a government project and the power generation project pursued as an investment project.

To ensure the feasibility of the project, it is proposed to separate the irrigation project from the power generation project. The irrigation project will be implemented as a government project, while the power generation project will be pursued as an investment project.

Despite efforts to improve investment conditions through reforms in related laws and regulations in the Kyrgyzstan investment environment analysis, factors such as the nationalization of existing investment projects, lack of substantive protection for foreign investors, outstanding debts from previous government projects, and the recently revised Renewable Energy Law which guarantees electricity sale prices for only an 8-year payback period, as well as changes in local conditions and stakeholder perceptions, suggest the need for careful consideration before proceeding with the project.

3. Future Plan

Kyrgyzstan's water resources have the potential to be a key element in the nation's long-term economic development strategy through the development of green energy. Today, the energy sector stands as one of the most promising aspects of the Kyrgyz economy, with the increasing importance of green energy in light of the deteriorating global environmental situation.

Therefore, the importance of water resource management in Kyrgyzstan is growing. Additionally, it's important not to forget that Kyrgyzstan is experiencing a trend of declining abundant water resources. Water resource management is also a crucial issue that must be addressed to ensure the country's sustainable economic, political, and environmental development.

Currently, only 10% of the potential hydropower capacity is being utilized for electricity production in Kyrgyzstan. It is due to insufficient infrastructure development for power transmission and distribution within the country. Hydropower is a field that utilizes renewable energy sources. Generally, harnessing Kyrgyzstan's hydropower potential can contribute to the country's long-term economic and environmental development in a promising direction.

However, to maximize this hydropower potential, measures need to be taken to modernize infrastructure, increase investment, and train experts in hydropower. Transparent and efficient management should also be a goal.

Utilizing water resources and developing infrastructure for hydropower can be an effective way for Kyrgyzstan to reduce dependency on imported energy and ensure energy security by developing environmentally friendly and efficient energy sources. It can also creates new opportunities for economic development and job creation, ultimately contributing to the country's socio-economic development.

Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

North and Central Asia

Uzbekistan

Agency of International Fund for Saving the Aral Sea for project implementation in Uzbekistan (Agency of IFAS)

1. Introduction

(1) Water Resources of Uzbekistan

Uzbekistan is one of the only two doubly landlocked countries in the world (to get ocean it is necessary to cross two countries), and has an area of 448,840 square kilometers.

Figure 1.1 Map of Uzbekistan

Uzbekistan is Central Asia's most populous country with over 36 million people (1 January 2024) – about half of total population in Central Asia. Rural population is 49 %.

In Uzbekistan, available water resources is formed by renewable surface and underground waters of natural origin, as well as by return water of anthropogenic origin. Water resources are mainly formed in the transboundary river basins. Uzbekistan very depended from his upper neighbors for water, as well as country has own available water resources less that 20 % of demanded for uses.

The country's total annual water withdrawal in the 1980s was about 65 km³. After gaining independence (in 1991), Uzbekistan clearly shows a tendency to decrease in water consumption and water withdrawal.

Table 1 Dynamics of actual water withdrawal from rivers (million m³)

1960		1980		1990		2000		2010		2018		2021		2023	
Total	Irrigation	Total	Irrigation	Total	Irrigation	Total	Irrigation	Total	Irrigation	Total	Irrigation	Total	Irrigation	Total	Irrigation
30780	27900	64910	55510	56611	58156	53265	35687	56611	44718	54700	50000	45300	39000	51200	44500

As a result of population growth, the specific indicator of water consumption per person in Uzbekistan significantly reduced – from 4270 m^3 (in 1980) to 1420 m^3 (in 2023).

After gaining independence in 1991 the government of Uzbekistan has undertaken the measures related to reforming the water and agricultural sectors. Those reforms were addressing to growth of agricultural production, and incomes of rural population. A lot of efforts were addressing to the maintenance and development of the enormous water management complex inherited from the past. But up to 2016 efficiency of water use (especially for irrigation) in Uzbekistan remained at very low level (FAO Report, 2021)[1].

By Decree of the President of the Republic of Uzbekistan № UP-5418 "On measures to radically improve the system of public management of agriculture and water resources" from 17.04.2018, the Ministry of Water Resources and the Ministry of Agriculture were established separately. The newly established Ministry of Water Resources (MoWR) became responsible for implementation of the unified national policy in the field of water resources management, as well as coordination of all activities in the field of rational use and protection of water resources, prevention and elimination of harmful impacts of water, raising the level of water use culture.

Decree of the President of the Republic of Uzbekistan, dated July 10, 2020 approved the Concept of the development of the water sector of the Republic of Uzbekistan for 2020-2030.

Approval of the Concept and three-years Water Strategy is an important milestone in reform of water sector in Uzbekistan. It provided a set of priority measures aimed at implementation of fundamentally new ideas and ways of further development and modernization of the sector, practical introduction of IWRM principles, market mechanisms and information technologies, as well as strengthening of regional cooperation to ensure efficient and sustainable use of water resources in Uzbekistan and combat climate crisis.

The Uzbekistan's achievements in the sphere of water resources management appreciated by the world water community. That was confirmed by active participation and contribution to activities of international water organizations such as the World Water Council, Asia water Council, Global Water Partnership, International Commission on Irrigation and Drainage, International Network of Basin Organizations, Asian Pacific Water Forum, etc.

2. Selected Completed Projects

(1) National Water Resources Management Project in Uzbekistan, Phase II (NWRM)

a. Description

The NWRM project Phase II (January 1, 2020 - December 31, 2023) was implemented as a logical extension of Phase I (January 1, 2017 - December 31, 2019) and contributes to the Swiss Cooperation Program for Central Asia 2022-2025. The overall project goal is to improve the rural population's livelihoods through integrated water resource management in Uzbekistan. The project activities foresaw two outcomes: Outcome 1: The Ministry of water Resources implements a comprehensive strategic and regulatory framework based on Integrated Water Resources Management principles and Outcome 2: Farmers and Water Management Organizations use water resources efficiently and sustainably. The project was implemented by Agency of IFAS.

1 https://www.unwater.org/publications/progress-on-water-use-efficiency-641-2021-update

b. Challenges

The project increased nationwide outreach, focused on highly relevant state priorities, and achieved considerable progress despite external factors. The Government of Uzbekistan has fostered the implementation of the wide-ranging reform process by endorsing the new Uzbekistan Development Strategy 2022-2026. Project efforts were targeted to support water sector reforms and ensure water security per the IWRM-based strategic framework, including Water Sector Development Concept 2020-2030 and Water Resources Management and Irrigation Sector Development Strategy. Crucial for the project interventions are advancements in introducing water-saving technologies, digitalization, and gender mainstreaming. To enable implementation of the IWRM-based strategic and regulatory framework, drafting of the new Water Code of Uzbekistan was supported.

c. Solutions

Established through the Project, the Information and Analytical Resource Center under the Ministry of Water Resources of Uzbekistan has become a vibrant think tank, knowledge bearer and facilitator of water sector reform. The Government was supported in its gradual progress towards the goals set by the Water sector Concept 2020-2030.

To make timely and resource-saving decisions, the concept of an integrated National Information System for Water Resources Management has been developed, implemented, approved and gradually implemented.

The land reclamation information system was developed and implemented into day-to-day practice of Reclamation Expeditions of the Ministry of Water Resources. Training sessions on using the system were conducted for local staff.

To facilitate introduction of irrigation water saving technologies, rational water use and increased water productivity a Mobile Application TOMCHI has been developed. TOMCHI in Uzbek language is meaning "drop of water". The Mobile Application tool designed as a virtual Extension Service for Farmers.

New courses and unique textbooks with teaching curricula on water saving technologies were provided to all water management colleges of Uzbekistan, as well as demonstration sites were built and laboratories were equipped in nine colleges.

(2) Project "Uzbekistan Water Security Outlook 2020" on the example of Navoiy, Samarkand and Khorezm provinces

a. Description

The project was supported by UNESCO and implemented by Scientific-Information Center of ICWC. Duration of the project: November 11, 2021 – March 31, 2022 (Khorezm province), May 20- July 1, 2022 (Navoiy and Samarkand provinces). Project objectives: 1) Preparing a database using statistics and information available at national and international level for assessing water security; 2) Drafting the 1st version of the "Uzbekistan Water Security Outlook", identifying the list of necessary data/recommendations for more accurate/detailed assessment of water security; 3) Developing a template for Water Security Concept. 4) Preparing the Uzbekistan Water Security Outlook on example of Navoiy, Samarkand and Khorezm provinces.

The project methodology has been based on the approach of Asia Water Development Outlook (AWDO) elaborated by the Asian Development Bank[2]. This methodology adapts ADB water security indicators to

2 https://www.adb.org/publications/series/asian-water-development-outlook

territorial characteristics of water management and the targets set in the national strategies and concepts of the development of agriculture, forestry, water, and green economy and other fields in Uzbekistan.

b. Challenges

Analysis of the water security index in the three selected provinces shows that, in general, over the period of 2010-2020, the consolidated water security index in these provinces remained at "engaged" level. At the same time, there was observed some declining trend change in the index in Navoiy and Samarkand provinces, and, on the contrary, the index improved in Khorezm province from "inadequate" to "engaged". The decline in the water security index in the three provinces was mainly due to the key dimension of human capacity for water security. In addition, household water security in Samarkand and Khorezm provinces, as well as environmental water security in Samarkand and Navoiy provinces also contributed to this decline.

c. Solutions

To improve water security in the three provinces, Project recommended to pay attention to some challenging issues for water security. First, to increase quantity of hydrological and meteorological observation points to improve water monitoring and accounting; ensure accessibility and transparency of the data on all water security dimensions; it is important to have spatially disaggregated data on all indicators and sub-indicators for more reliable assessment of the security level of key dimensions and tracing of their dynamics.

Second, against the background of continuous population growth, construction of new residential areas, expansion of cities and settlements, it is necessary to take effective measures to radically improve the water supply system. This implies modernization and advanced development of diversion structures, off-takes, pumping stations, distribution units and water supply networks based on intensive introduction of modern energy and resource-saving technologies.

Third, increase efficiency and productivity of land and water use to meet the growing water demand of the population and the economy by improving water management and water use in all economic sectors (i.e., improving the key dimension of economic water security to effective or model level).

Forth, improve performance of inter- and on-farm canals, irrigation and collector-drainage systems (reconstruction, rehabilitation, coating, transfer to the private sector) and increase the pace of application of water conservation technologies; improve water diversion and transportation and irrigation technique and technologies by applying science evidence-based irrigation regimes and advanced technologies; revisit current irrigation regimes and water duty zoning, taking into account the changed crop production conditions (crop diversification, sowing of new crop types and varieties for which no irrigation depths were set in irrigation regimes), water and soil conditions (groundwater bedding), and applied water-saving technologies.

And some others.

(3) Green Rehabilitation Investment Project for Karakalpakstan Republic to address impacts of the Aral Sea crisis

a. Description

The project is funding by the Korea International Cooperation Agency (KOICA) and the Global Green Growth Institute (GGGI). The project aims to assist the green rehabilitation of the Republic of Karakalpakstan in addressing the impacts of the Aral Sea ecological crisis. The project is going to establish viable measures to

allow communities of the most disaster afflicted districts to pursue disaster resilient sustainable livelihoods through climate-resilient agri-business models. It will also provide the policy, financing, and investment frameworks to allow these to be scaled up. The project supports disaster-risk reduction, improve food security, and enhance livelihoods and job creation in an integrated approach by integrating the dissemination of well-established climate smart agriculture techniques that will increase yields with support for enabling environments for emergence of climate resilient farmers and micro-, small-, and medium enterprises (MSMEs). Project duration: July 2021 - June 2024 (36 months), Budget: USD 5.6 million from KOICA, USD 0.3 million from GGGI.

b. Challenges

Targeted area of the project - the Republic of Karakalpakstan, which is a sovereign state within the Republic of Uzbekistan. It is located in the northwest of the country on the Amu Darya flatlands and southern shores of the Aral Sea. The climate is naturally arid, so the local population has long depended on water from the Amu Darya delta for irrigation in agriculture, and in the past – from the Aral Sea for fishing. With the drying up of the Aral Sea and reduced inflows to the lower reaches of the river, the livelihoods of local populations are increasingly threatened, and numerous interconnected human security concerns have emerged. The project work addressing to residents of four selected districts involved, among other activities, in the production and processing of agricultural products. Through climate resilient agri-business models, the project will benefit rural farmers, as well as rural and urban entrepreneurs, who have established or are willing to establish MSMEs for production and processing of agricultural produce into value added products.

c. Solutions

The project interventions aim to achieve the following objectives:

- Establish an effective green rehabilitation investment plan targeted on agriculture and agri-businesses that reduces disaster risk, enhances rural food security and sustainable livelihoods, and promotes equitable employment in green and climate-smart value-chains in Karakalpakstan;
- Respond to the most urgent needs of the workforce and micro-, small-, and medium enterprises (MSMEs) to tackle pressing human security needs, focusing on disaster-related threats to health, livelihoods, productive assets, and agri-business risk management.
- Demonstrate viable climate-resilient agri-business models to rebuild the economic foundation of Karakalpakstan's agrarian economy;
- Support the government and banks in mobilizing green/climate finance in support of green MSMEs development in Karakalpakstan

(4) Project "Construction of irrigation system for household plots (65 hectares) of residents of the city of Muynak with a pressure polyethylene pipeline network with a diameter of 250 mm."

a. Description

Muynak is a small city in Karakalpakstan (North of Uzbekistan) on the former shore of the drying Aral Sea. Once a port city, today it has the status of a city-museum and is a silent reproach for all humankind, an evidence of a huge ecological catastrophe. Approximately 30,000 people live here. As a result of the project, a Pumping station with pump machine SNPE 500/10-1 brand was build and 13,761 m of polyethylene pipes with a diameter of 250 mm

were installed along the Muynak city.

b. Challenges

In spite of the Aral Sea tragedy, the city is gradually developing: new and modern houses, hotels, cafes, schools and kindergartens are being built, urban infrastructure is being improved, roads are being restored, and parks are appearing. Nowadays, the northernmost airport of Uzbekistan - Muynak - has been reconstructed.

c. Solutions

The goal of the project is to provide irrigation water to household plots of residents of the city of Muynak, as well as green spaces along the highway and areas around administrative buildings in the city of Muynak. The construction project was implemented by Agency of IFAS during 2019-2021 using funding from the Uzbekistan's state budget as a contribution to the IFAS (International Fund for saving the Aral Sea).

3. Description of Mobile Application «TOMCHI»

To facilitate introduction of irrigation water saving technologies, rational water use and increased water productivity a Mobile Application «TOMCHI» has been developed within the framework of the National Water Resources Management Project financed by the Swiss Agency for Development and Cooperation and implemented in partnership with the Ministry of Water Resources of Uzbekistan and Agency of IFAS. Tomchi in Uzbek language is meaning "drop of water".

The Mobile Application tool designed as a virtual Extension Service for Farmers providing the following tools: (i) access to comprehensive information on applicable in the local context water saving technologies, relevant legislation and best practices; (ii) estimation of respective costs of certain water saving technique implementation; (iii) feedback mechanism and (iv) platform linking water users with local producers and service providers of available water saving technologies.

Mobile Application «TOMCHI» is software designed to work using smartphones and other mobile devices. It works in smartphones running on Android and iOS platforms. For smartphones running on the Android platform, the application can be downloaded from the Google Play Market, and for smartphones running on the iOS platform from the Apple Store (Figure 2).

Mobile Application (MA) «TOMCHI» includes information on modern water-saving technologies for irrigation, such as drip, sprinkling and subsoil, also water-saving methods for traditional for Uzbekistan furrow irrigation, such as alternating irrigation and dry inter-row irrigation, short-furrow irrigation and variable-sprinkler irrigation. The MA

Figure 3.1 Mobile Application «TOMCHI» (just use the Google Play Market)

suggests to use various technical means for furrow irrigation widely used in Uzbekistan, such as the use of flexible irrigation hoses, discrete irrigation, irrigation using furrow-shielded polyethylene film and the use of moisture-retaining hydrogels.

The MA (Interface in Uzbek language) provides information on methods for determining the irrigation time/scheduling for different crops, information on field activities/cultivations that contribute to water conservation. Also, the MA provides information on local manufacturers who produce water-saving irrigation systems, information on service providers for the implementation of water-saving irrigation systems, as well as information on incentives for the implementation of water-saving irrigation systems supported by Government of Uzbekistan.

MA TOMCHI includes a number of sections. The first one is section "Water-saving irrigation methods", which consists of two sub-sections:

The sub-section "Modern Water-Saving Irrigation Methods" provides detailed information on modern advanced water-saving irrigation methods, such as drip irrigation, sprinkler irrigation, subsoil irrigation, the use of flexible polyethylene hoses and films for furrow irrigation, irrigation using water-retaining hydrogels. Each part of the sub-section describes in detail the presented irrigation method, its advantages, the conditions for their applicability, the constituent elements of the irrigation method, the rules for the design, specifics of construction and operation of certain irrigation system.

The sub-section "Water-Saving Methods of Traditional Irrigation" provides information on water-saving methods of traditional surface furrow irrigation (gravity irrigation), in particular, water-saving methods (irrigation by alternating water and dry rows, irrigation using short furrows and irrigation with a variable stream).

Section "Enterprises". This section provides information on the main local manufacturers who produce elements of water-saving irrigation systems. The section includes detailed information and contacts of the main manufacturers / factories, design organizations and service providers. The section also provides examples of the most successfully implemented in local conditions technologies and results and lessons from functioning water-saving irrigation systems.

Section "Governmental Incentives to Support Water Conservation". The section highlights governmental efforts to stimulate wide practical introduction of water-saving irrigation systems, in particular drip irrigation systems. In Uzbekistan, farmers (agricultural producers) using traditional irrigation methods to grow crops usually do not pay for water, but pay a Unified Land Tax. For farmers using water-saving irrigation technologies, in particular, introducing a drip irrigation system, a privilege has been established by Government for exemption from the payment of a Unified Land Tax for a period of 5 years.

The section also provides information on the provision of soft loans and subsidies (in the amount of 50% of the installation cost) to farmers who are going to install drip or other water-saving irrigation methods. At the same time, the information in this section is constantly updated in the light of new decisions by the government to promote water conservation.

Section "Setting Schedule of Irrigation". This provides information for certain farmer on determining the timing of irrigation for crops based on a visual assessment of changes in soil conditions and crops grown at the particular field. That is done on the basis of instrumental measurements of changes in soil moisture, which farmer should put into MA.

The section also provides recommendations on methods for assessing changes in soil moisture using various laboratory devices, such as thermostats, remote sensors and cameras to determine the suction pressure in plant leaves.

Section "Promotion of Measures for Water Conservation". This provides information and recommendations on measures that effectively contribute to water conservation. The section provides information on soil cultivation measures both before sowing and during the vegetation of plants, which contribute to reducing water infiltration into the deep layers of the soil. Information is also provided on measures that contribute to reducing the evaporation of moisture from the soil surface. As such, measures are presented for tillage (inter-row cultivation of the soil) and the use of various materials to cover the soil surface (mulch) and measures to reduce the wind force over the surface of the irrigated field (use of forest strips).

Section "Calculator". In this section, users who want to install water-saving irrigation technologies at their irrigated fields, in particular, a drip irrigation system, can determine the approximate cost of purchasing and installation of drip irrigation system.

The calculator takes into account various types of crops and various options for planting schemes. At the same time, in drip irrigation systems for orchards and gardens, irrigation hoses with special drippers are suggested, for field drip irrigation systems that are designed to irrigate field crops with a wide-row planting pattern, irrigation hoses with ordinar droppers are used. Knowledge about the price of drip irrigation systems allows farmers to make decisions on attracting investments for introducing drip irrigation systems and successfully conclude contracts for the installation of drip irrigation systems.

The section of the mobile application "Useful Links" provides information about the legal framework (legislative acts) useful for farmers' water management. This section also presents various newsletters, recommendations and guidelines promoting the rational use of water resources.

The latest version of the mobile application also presents the "News" section, which publishes various interesting information and stories about effective methods of using water resources. This section is updated daily with new information from around the world.

4. Future Plan

(1) Global Challenges

On May 18, 2021, the UN General Assembly adopted a special Resolution 75/278 "Declaring the Aral Sea region a zone of environmental innovations and technologies". The concept of such zone is effective mechanism for implementation of the principal post-2015 intergovernmental agreements which Uzbekistan signed with responsibility – namely: 2030 Agenda and Sustainable Development Goals, Paris Agreement on Climate Change, and Sendai Framework on Disaster Risk Reduction 2015-2030 - for the Aral Sea Basin.

(2) Future Action

Uzbekistan is fundamentally changing the ideology of solving the Aral catastrophe: we do not just draw attention to the ecological crisis in order to reduce its negative consequences, but create a mechanism to eliminate it. The Concept "Declaring the Aral Sea region a zone of environmental innovations and technologies" coverage area is the whole Central Asia, taking into account common regional approach to implementing measures in the Aral Sea basin, with priority results aimed to improving socio-economic and environmental situation in the Priaralye. There

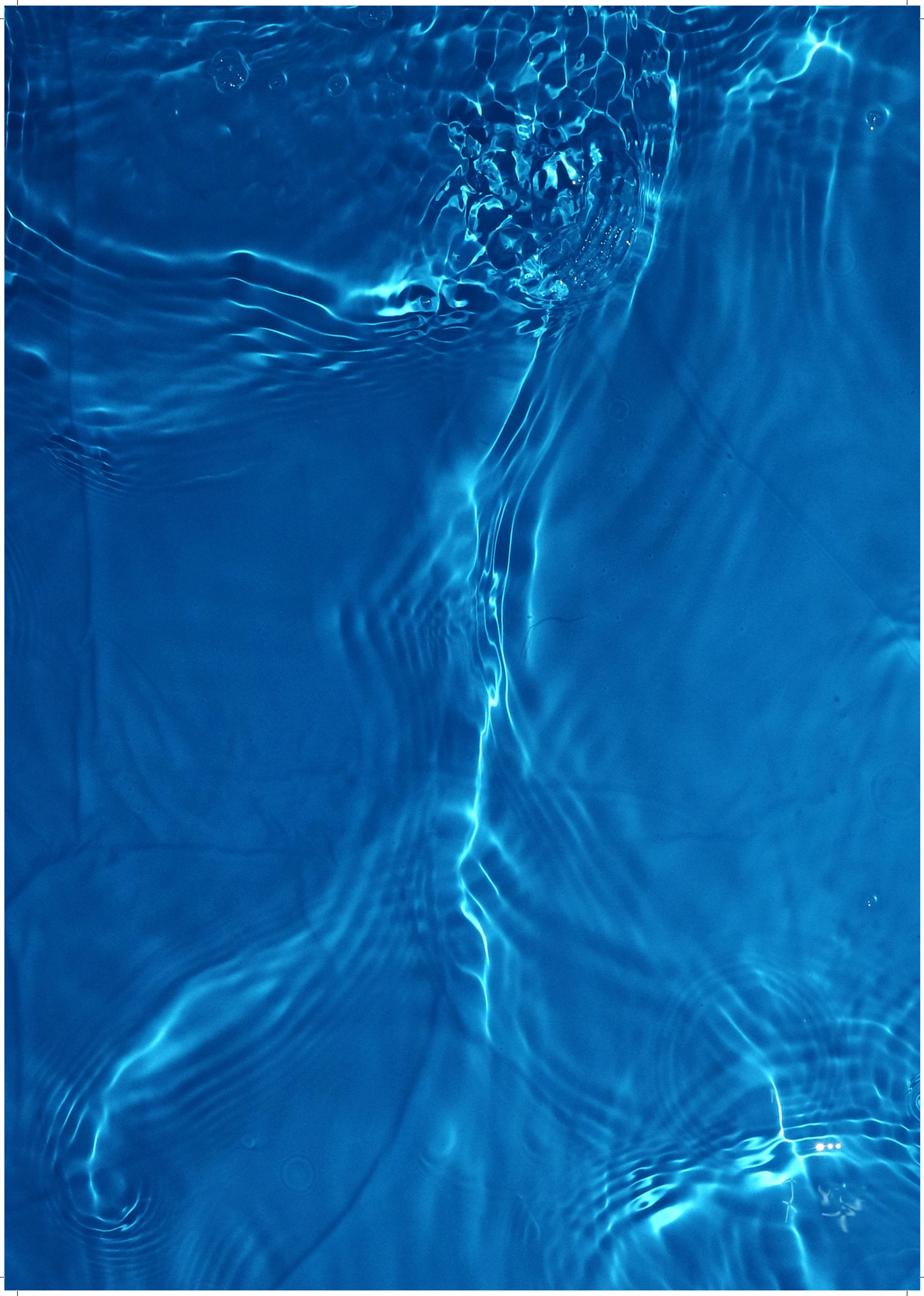
is need for fundamental change in practice and scope, which can lead to restoration and functional integrity of ecosystems which are the basis for socio-economic development in the Aral Sea region. Strategic priorities for development of innovations in the Aral Sea region:

- creation of legal and regulatory framework
- creation of financial system for attraction innovations
- creation of scientific platform for the Aral Sea region
- growing qualified personnel and support networking among research institutions and universities, stimulation of creativity.

The operationalization of the Concept will lead to transformational and sustained improvement in quality of lives and livelihoods of people in the Aral Sea region and restoration of a vibrant ecosystem and increased biodiversity of the Aral Sea basin.

Theory of change of the Concept is to develop a coherent, flexible Aral Sea Region Innovation Platform, adopting innovation approach to empower diverse groups of people to change practice, through exploration, experimentation and deep demonstrations. Initially in Karakalpakstan and then engaging the wider Aral Sea region, building on the Human Security Principles.

Our collective efforts in the Aral Sea region can be an inspiration for transformative, systems innovation approaches in other complex crisis regions across the world.



Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

Oceania

Australia

Australian Water Partnership
(AWP)

1. Introduction

(1) When the Murray–Darling stopped flowing

Australia is a land of droughts and floods, deserts and rainforests, rivers and salt lakes. As the driest inhabited continent on earth, Australia has considerable experience in managing scarce water resources. Water scarcity, competing demands, extreme weather, and the unpredictability that climate change brings all mean Australia's water management measures must be adaptable, allowing for reduced water availability in the future.

The Millennium Drought of 1996–2010 was a pivotal in Australia water resource management. During this time the Murray River stopped flowing to the sea, forcing sovereign states, territories, and the national government in Australia to work together and quickly adapt and embed their experiences into legislation. Australia now has measures in place to allow for a quick response when water availability suddenly declines.

Australia's transition to a modern water management approach can be broadly divided into pre- and post-Millennium Drought. Before the drought, water resources were approached with a build and expand approach. This resulted in significant infrastructure projects such as the Snowy Mountains Scheme and Gordon River dam. The Millennium Drought irrevocably refocused Australia's approach to manage water from an allocation perspective. This required all users in the system to be allocated a share in the resource, including critical human needs, environmental and recreational needs. This involves measuring what water is available at any given time and establishing a framework to share it between sovereign bodies (states and territories) and from there share between the different types of users. Since this water allocation approach has been implemented, the Murray–Darling Basin has maintained a flowing river that connects to the sea, even during the driest 3 years on record (2017-19).

Most recently Australia has been focusing its efforts in five areas of water reform, including:

- Refining interjurisdictional water governance arrangements such as renewing the National Water Initiative and reviewing the Murray–Darling Basin Plan.
- Investing in transparent, joined up monitoring and science across jurisdictions. Creating a common language and foundation from which to build water planning.
- Re-thinking water infrastructure and investing in climate resilient and water efficient methods for distribution and storage.
- Improving urban water use efficiency by developing product labelling and standards for fittings and appliances.
- Valuing water appropriately. Reframing water's value using the economics of supply and demand. Establishing accounting and market frameworks.

Section 2 of this report further details these reform approaches and Section 3 provides further detail on the water governance processes established in Australia, alongside improved water efficiency using product labelling and standards.

2. Australia's five areas of focus

(1) Interjurisdictional water governance

Water reform in Australia accelerated during the Millennium Drought of 1996–2010. During this time the federal government, four sovereign states and one territory agreed there was a need to manage water carefully and protect the Murray–Darling Basin for future generations.

A landmark water reform framework was developed to balance allocation of water resources between all uses and improve the health of river systems across Australia. This framework was built on the 2004 National Water Initiative which was agreed by all states and territories introduced water pricing and improved service delivery. The framework aims to provide investment confidence, supply security for rural and urban communities, and provide greater certainty for the environment.

Then the Water Act was established in 2007, this required the Murray–Darling Basin Authority (a body established under the Water Act) to prepare a strategic plan for the integrated and sustainable management of water resources. The Basin Plan 2012 manages the Basin as a connected system. The aim of this plan is to bring the Basin back to a healthy and sustainable level, while continuing to support farming and other industries for the benefit of the Australian community. The passing of the Water Amendment (Restoring Our Rivers) Act 2023 by the national Parliament in December 2023 provides more time, flexibility and accountability to ensure the Basin Plan will be fully implemented; and using more tools to deliver the plan's outcomes.

Almost 20 years on, the Australian Government has committed to renewing the National Water Initiative. Alongside this process, the Murray–Darling Basin Plan is being reviewed and will be updated by 2026. Both processes will accommodate climate change, First Nations Peoples involvement and incorporate the latest science on water requirements of various users including native fish and vegetation. Further information on interjurisdictional water governance in Australia is provided in Section 3.

(2) Investment in Science

Investment in water science and knowledge underpins the evidence-base that enables policymakers to make informed decisions to protect and secure Australia's water resources into the future. A common understanding of water from a scientific perspective assists stakeholders and governments to agree on solutions to difficult problems. Climate change, more extreme weather patterns, changes to water use and demand are collectively affecting water systems with significant impacts on the quality and quantity of water resources and their dependent ecosystems. In response to these challenges, Australia's water science and knowledge brokers are preparing tools and expertise to accurately monitor, collect data, and better understand a range of possible national water system future scenarios.

Under the Water Act 2007, the Australian Government collects, holds, manages, interprets, and disseminates Australia's water information to ensure water data is publicly accessible to the Australian community. Public transparency of water information held by the Australian Government fosters inclusive, collaborative, and constructive relationships between governments, scientists, First Nations, and the community which contributes towards better informed water consumption decisions by water users and progresses the collective aim of achieving sustainable outcomes in water management policy and planning.

(3) Investing in climate resilient and water efficient infrastructure (National Water Grid)

A careful and considered approach to investment in water-efficient and climate-resistant infrastructure is resulting in immediate and long-term water security for Australians. The National Water Grid Fund (the NWGF) is the Australian Government's primary program for investing in the development and delivery of vital water infrastructure.

Investing in nationally important, and locally critical, water infrastructure projects improves Australia's water security, through delivering better access and increased water availability and improved climate resilience. Through the NWGF, the government is investing in projects right across the country, including essential town water, dams, weirs, pipelines, water recycling and treatment plants and other water storage, distribution, efficiency and scientific solutions.

Investment decisions are made based on leading scientific evidence, underpinned by the National Water Grid's Science Program, comprehensive business case and planning work. Projects are considered based on the cultural, social, economic and environmental outcomes. Completed in November 2023, the National Water Grid funded Rookwood Weir is a great example of a project delivering against all of these outcomes.

NWGF investments are also helping to Close the Gap on access to safe and reliable water for First Nations communities. Supporting First Nations communities on Country, particularly those in some of the most remote parts of Australia, requires a collaborative effort between federal, state, territories and local governments to make sure investment is effective and culturally responsive. The Australian Government, through the NWGF, has invested $150 million to support water infrastructure for First Nations communities in regional and remote Australia.

(4) Improving efficient urban water use through product water efficiency labelling and standards

Significant volumes of water are being saved across Australia through mandatory water efficiency labelling of household products at the point of sale. The legislated Water Efficiency Labelling and Standards (WELS) scheme reduces demand by providing a star rating and water use information to consumers when they are purchasing products such as taps, showers, toilets, urinals, flow controllers, washing machines and dishwashers.

The scheme includes minimum water efficiency for the fittings and appliances that can be sold in Australia. The scheme is mirrored in New Zealand and supported by Australian and New Zealand Standards. Building and plumbing regulations also mandate the minimum water efficiency of the plumbing products that can be installed, based on the product WELS ratings.

Since commencing in 2005, the total water saved is estimated to be 1,658 gigalitres, that is over 650,000 Olympic sized swimming pools worth of water. The scheme is expected to save more than A$2 billion in utility bills by 2030. The scheme is managed by the Department of Climate Change, Energy, the Environment and Water, working in partnership with industry and state and territory governments.

Consideration is also being given to minimum water efficiency requirements for fit outs and maintenance in government procurement.

(5) Valuing water through water accounting and markets

To optimise management of Australia's water resources, water rights were separated from land ownership rights to enable parties to buy or sell water on a permanent or temporary basis. This is controlled by the Water Act 2007. Water trading allows irrigators to use water where it is needed most, particularly in drier years. The water market allows irrigators to increase their water supplies and expand production or sell their water for income or to further invest in their businesses. The trading of water between irrigators promotes efficiency and delivers broader benefits to the Australian economy.

Australian water markets are among the most extensive and complex in the world and depend on Australia's system of water tenure. Water trading is managed within a complex regulatory and operational framework. It allows for constraints of the physical system and to avoid detrimental environmental impacts. The flexibility and autonomy offered by water trading has increased agricultural production, helped farmers and communities to survive severe drought, and provided the mechanism to recover and manage water to meet environmental needs. This encourages the best use of our scarce water resources. Australia's water markets have grown rapidly over the last 30 years. In 2020–21, the estimated annual market turnover was $6 billion, The estimated value of water entitlements in the southern part of the Murray–Darling Basin is $32 billion. The value of the environmental water portfolio, managed by the government, is worth about $3.3 billion.

3. Detail of Australia's Water Governance arrangements

(1) National Water Initiative and Murray Darling Basin Plan

a. Description

National Water Initiative

The 2004 National Water Initiative is an intergovernmental agreement between the Australian Government and all state and territory governments. The NWI sets out the framework and principles for state and territory governments who are responsible for managing water resources within their jurisdictions. Under the NWI, all states and territories committed to:

- prepare water plans with provisions for the environment
- achieve sustainable water use in over-allocated or stressed water systems
- introduce registers of water rights and standards for water accounting
- expand trade in water rights
- improve pricing for water storage and delivery
- better manage urban water demands.

Murray Darling Basin Plan

The Murray–Darling Basin covers 1 million sq km of south-eastern Australia and contains Australia's three longest rivers.

This is Australia's most iconic river system, ensuring a sustainable and healthy Murray–Darling Basin is critical for the livelihoods and welfare of millions of Australians, and for our environment. That's why Australia developed a

basin-wide plan during the water scarcity experienced during the Millennium Drought. The plan aims to bring the basin back to a healthier and sustainable state by ensuring enough water is left in the environment to support the rivers, lakes, wetlands and the plants and animals that depend on them, while also supporting the communities that rely on the basin.

Figure 3.1 Catchments of the wider Murray-Darling basin (Source: MDBA)

b. Challenges

Prominent and widely publicised fish kills in the basin demonstrate, despite Australia's efforts dedicated to the Murray–Darling Basin, there is still more work to be done. Designing, developing, implementing, and evaluating any kind of plan to restore environmental health alongside of developing urban regions, mining, and changing demands of commodities is complex. This is compounded by the transboundary issues that come with many state boundaries and territories sharing the same catchments/basin. This can be for surface and groundwater catchments.

The unpredictability of water resources in Australia is the overall challenge to any governance within all surface and groundwater catchments across the country. The current water reform tools do not sufficiently incorporate the looming impact of climate change or the knowledge of First Nations Peoples.

In Australia, water requires collaborative agreement and consensus. This becomes increasingly difficult when differences exist between various stakeholders. The national government cannot resolve disputes simply by overruling objections. Adherence to a catchment plan requirements and agreement becomes a cooperative effort, rather than an enforcement one. Administering such a vast and complex system this way requires patience, acting in good faith, and commitment to stakeholder engagement. The achievements of the NWI and the MDBP are a testament to Australia's approach.

c. Solutions

The National Water Initiative is in the process of being renewed, while the Murray–Darling Authority has begun reviewing the Basin Plan which is due to be completed in 2026.

Renewing the NWI will ensure a consistent approach to water management by establishing agreed principles to guide water reform in all jurisdictions, including the Murray–Darling Basin review, on such important issues as:

- water security for all communities, industries and the environment
- First Nations Peoples' interests in water resource management
- a water management framework that can respond to future challenges like climate change
- effective use of quality science and data to support decision making
- public benefit government investment in water infrastructure projects.

As part of this process the Australian government is working with the Committee on Aboriginal and Torres Strait Islander Water Interests (CAWI) to co-designing a First Nations-specific engagement process to ensure First Nations peoples' views are thoroughly and thoughtfully considered in the development of a new NWI.

4. Detail of the Water Efficiency Labelling and Standards Scheme

(1) Improving urban water efficiency with product labelling and standards

a. Description

Australia needs to make sure every drop of water use count. One step towards this goal was the development of a mandatory product labelling scheme that allows Australians to choose more water efficient household appliances and plumbing fittings when shopping in store or online.

All products wishing to promote their water efficiency on the Australian market must be tested in a laboratory against Australian and New Zealand standards. Industry must apply to register the product with the Australian Government Water Efficiency Labelling and Standards scheme (WELS) Regulator with the appropriate evidence and to pay to have it registered. These charges fund the administration of the scheme.

If the product meets the requirements, it is given a water efficiency rating that must be advertised on the WELS label (or in the product specifications) when it is offered for sale online or in store. The more stars the more water efficient the product is. The simple label helps consumers easily identify and compare the water efficiency of similar products.

Figure 4.1 Example of water rating label (Source: WELS)

In addition to the labelling, the WELS Regulator has set a minimum standard water efficiency for the sale of products, so that inefficient products cannot be registered or sold.

A similar process is set for plumbing products by building and plumbing regulations that regulate the minimum water efficiency of fittings that can be installed in buildings. For example, since 2015 it has been illegal to install a showerhead or tap that has a flowrate higher than 9 litres per minute (a WELS 3-star rating).

The scheme is also integrated with the minimum energy efficiency for washing machines and dishwashers because they are regulated under the Greenhouse and Energy Minimum Standards Act 2012. Through a single testing protocol, washing machines and dishwashers must meet the minimum water and minimum energy requirements to be offered for sale, and display the labels for both schemes.

b. Challenges

The WELS scheme started as a small voluntary scheme in 1988 in one of eight states and territories, led by a water utility company. The scheme provided water efficiency information for showerheads. Over two decades, the scheme grew to include most of the indoor household water using appliance and fittings – taps, showers, toilets, urinals, flow controllers, washing machines and dishwashers.

Unfortunately, there was not enough voluntary uptake of the scheme by industry. Companies were not registering their products and consumer awareness about water efficiency was low. The tipping point came a few years into the Millennium Drought, which devastated many communities, industries and large areas of the country.

c. Solutions

The Millennium Drought led to the Australian Government taking the lead in legislating the WELS scheme. It became a mandatory national scheme under the Water Efficiency Labelling and Standards Act 2005. The WELS Act was then supported by complementary legislation in all Australian states and territories to ensure a nationally consistent framework.

The Government of New Zealand legislated the New Zealand Water Efficiency Labelling Scheme that recognises products registered and labelled for the Australian market can also be used for the New Zealand market. This supports the Trans-Tasman Mutual Recognition Agreement for trade between the countries.

In 2017 Australia led 37 other nations to develop the world's first international standard for establishing water efficiency labelling programs, ISO 31600:2022. This standard provides guidance and examples for countries who want to establish their own water efficiency labelling program.

The WELS label has now completely penetrated the Australian market. Australians expect to see the label on products, particularly on larger displayed items such as toilets, dishwashers and washing machines. Market research shows that more than 80% of Australians are aware of the WELS label and use it to buy water efficient products.

Given that the scheme was designed to save water, it has been highly successful. In 2024, the WELS scheme is expected to save 172 gigalitres of water across Australia or about 18 litres per person per day. Since commencement in 2005, the total water saved is estimated to be 1,658 GL.

The scheme also helps those in remote communities living off-the-grid who rely on rainwater, tanks or dams for their water supply to make their water last longer.

Reducing the water used also means savings on both water and water heating bills. This is expected to save Australians more than $1.6 billion in 2024. That is a saving of about $155 per Australian household this year.

The carbon emissions reduction from reduced energy consumption is also significant. The scheme is expected to prevent 2.39 megatonnes of carbon dioxide equivalent1 being emitted this year.

Reducing water consumption helps to reduce the impact from growing urban populations. It supports deferral of water infrastructure investment while also reducing the amount of wastewater needing treatment. We are working towards adding new products to the scheme so that more water, as well as energy and money, can be saved. More information on the scheme is at waterrating.gov.au

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Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

Oceania

Solomon Is

Ministry of Infrastructure Development
(MID)

1. Introduction

(1) Water Resources of Solomon Island

Solomon Islands in a large archipelago of almost 1,000 islands with a population of 721,455 people, of which 25.6% live in urban areas and 74.4% in rural areas. A dozen of the islands can be considered large in Pacific terms with a coastline of 5,313 km and land area of 27,549 km². It has a territory covering 910 km² of ocean and a 321 km exclusive economic zone (EEZ) of 1.3 million km². The Solomon Islands was declared a British Protectorate in 1893. It was granted independence in July 1978 after 85 years of colonial administration. The first European to visit this group of islands was a Spaniard named Alvaro de Mendana in 1567 (Bennett 1987).

Like many other Pacific Island Countries, the Solomon Islands has two distinct seasons, and the average temperature is 27 degrees Celsius. The main feature of temperature in the Solomon Islands is its uniformity, with seasonal variation extremely small, and little variation with latitude evident. The range of average maximum temperature is approximately 2 degrees Celsius throughout the year. The range of minimum temperature is almost the same. The mean daily range of temperature (or diurnal variation) is about 7 degrees Celsius. The differing exposure of each station to the prevailing wind and the effect of local topography in causing a downhill flow of cooled air at night at some stations are the main reasons for the variation between stations. Although no temperature data for elevated stations are given here, a decrease of mean monthly temperature (calculated as the average of monthly maximum and minimum temperatures) of about 2 degrees Celsius for each 300 meters of elevation has been found in many tropical areas of the Solomon Islands.

The wet season is usually from November to April, and the drier season is from May to October (SIG, 2021). The average annual rainfall is mostly within the range 3000 to 5000 millimetres with the majority of monthly rainfall amounts in excess of 200 millimetres. In most of the Solomons, the wettest months are during the Northwest monsoon season, with a tendency for reduced amounts during February when the equatorial trough is normally furthest south. Places on the southern sides of the larger islands also tend to have a rainfall maximum between June and September. As there are no elevated rainfalls stations (with long-term averages) the effect of increasing rainfall with height above mean sea level is unrecorded. Depending on the local topography, rainfall could be expected to increase with elevation with a maximum at about 600 to 1000 metres level on windward slopes. It is possible that the heaviest average yearly rainfall could reach 9000mm at some elevated sites. The extreme falls seem to be confined to the transition months of December and April when the equatorial trough is migrating across the islands. Between these months, the Northwest monsoon tends to give frequent rain but with lesser daily amounts. Very heavy daily falls can also occur during the South-easterly season at places well exposed to the prevailing wind. For example, the heaviest daily fall recorded, 380mm at Auki in April 1970, accounted for more than 40% of the station's rainfall for that month.

(2) Economics of Solomon Island

Solomon Islands has one of the lowest levels of gross domestic product (GDP) per capita among the Pacific Island states, at US$2,013/capita. The country is still recovering from many years of intermittent political turmoil and civil strife. Locally referred to as the "tension", the conflict during 1998-2003 disrupted the functioning of state and social institutions which resulted in a 40 percent decline of GDP. To support the stabilization of

Solomon Islands, neighboring countries led by Australia deployed the Regional Assistance Mission to the Solomon Islands to restore law and order and other basic state functions. Ever since, peace has generally been maintained, barring major riots in 2006 (which did not trigger further conflict), and political protests in 2011 following a change in prime minister.

2. Selected Completed Projects

(1) Tina River Hydropower Development Project

a. Description

The Tina River Hydro Development Project (TRHDP) is a National project of Solomon Islands, managed by a dedicated Project Office under the Ministry of Mines, Energy and Rural Electrification, MMERE. The TRHDP is part of a broader initiative called Solomon Islands Sustainable Energy Project, SISEP, and has as its objective the provision of electricity for Honiara from indigenous renewable energy sources (hydro) to provide more affordable and reliable energy options to the capital.

b. Challenges

- Co-financing risk. World Bank(IDA), ADB, GCF, EDCF, IRENA/AFDF, and APIP TF are concessional financiers.
- Construction risk. Construction could require extension of time due to adverse geological conditions of the dam foundation and tunnel excavation.
- Social risk. Customary land owners cound appeal compensation payments, despite the fact that the appeals period has ceased
- Environmental risk. The most significant environmental risks during project construction and operation will be the quantity and quality of water in the Tina River

c. Solutions

- Co-financing risk. The Bank and SIG are coordinating across donors to align processing schedules since delayed approval of funding sources could cause significant implementation start-up delays..
- Construction risk. Project Company will contract an Owner's Engineer responsible for ensuring timely and quality construction as well as safety, while the Project and SIEA will jointly finance an Independent Engineer to validate
- Social risk. SIG has taken a range of steps to ensure ongoing alignment of tribal interests in the Project including the provision of royalties, establishment of the proposed TCLC, and establishment of the proposed benefit sharing mechanism.
- Environmental risk. Impacts on terrestrial and aquatic wildlife, in particular, the presence of migratory fish, above and below the dam, will be monitored through regular Project Company reports, the safeguards experts contracted by MMERE and supported by the Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM).

(2) Urban Water Supply & Sanitation Sector Project

a. Description

Solomon Islands Government recognises that significant work is required to meet targets of the provision of safe drinking water and basic sanitation in Sustainable Development Goals (SDGs). As of 2012, 81% of the Solomon Islands was using an improved drinking water source, and only 29% were using an improved sanitation facility. In order to address this, the Government has developed a National Development Strategy to map out the strategic direction for the future development of the Solomon Islands.

b. Challenges

- The main focus in the water and sanitation sector is on the provision of public utilities to the urban and rural population so that the majority of the country's population can access the basic public utilities for their livelihoods.
- Increased accessibility to these public utilities will improve standards of living for Solomon Islanders and relatively reduce the potential epidemics of disease that have adverse impacts on the lives of Solomon Islanders and the development of the country.

c. Solutions

- Through the 30 Year Strategic Plan, SW has adopted a target of achieving 95% coverage of properties within its service areas with access to the reticulated water supply network. SW has also adopted a target of achieving 30% coverage of properties within Honiara with access to the reticulated wastewater network, including the majority of non-residential properties. This requires significant investment in new and improved water and sewer infrastructure.

(3) Digitalization of Water Management for Improved Resilience Capacity Building Program for Ministry of Infrastructure Development

a. Description

The capacity building program will be provided to the Ministry of Infrastructure Development of the Solomon Islands (the Ministry) by K-water to strengthen their institutional capacity in flood risk assessment and flood forecasting and early warning systems (FFEWS) for the Greater Honiara Area (GHA), particularly along the transport/service routes and associated drainage infrastructure. K-water's services will be provided in a phased approach based following an initial gap identification, diagnostic study and a needs and readiness assessment.

b. Challenges

- With a population of 100,000, the GHA (between Alligator Creek and Poha Bridge) is the most densely populated area in the country comprising Honiara, the capital city, and surrounding areas. It's the center of Solomon Islands' urban growth and hosts the main international gateway and main port of entry into the country. GHA is a locus of employment, public administration, education, and health services, and represents the largest single market for both local and imported products.
- The GHA is prone to natural hazards such as cyclones, heavy rain, strong winds, flooding, landslides, storm surge, and tsunamis. Most of the coastal area is identified as a 'storm surge risk zone.

c. Solutions

K-water will be responsible for carrying out the necessary services to deliver the program and subproject outputs as follows, in alignment with the TA scope, namely:

- Output 1: Digitalization in water resources and flood risk management systems enhanced. This output will support partner institutions in moving toward digitalization to improve operations, efficiency, and resilience. The selected entities will undergo gap identification or diagnostic study, a needs and readiness assessment toward digitalization, identification of entry points and a proposed support service plan. Upon agreement with the Ministry and ADB, subsequent support services will include building/enhancing the proposed flood forecasting system and implementation of pilot testing on new or expansion of existing ICT and digital and remote sensing technologies. Based on the results, an improvement and scaling-up plan will be prepared, including training and capacity building. This will help ensure the gains are sustainable and can be replicated.
- Output 2: Knowledge sharing and production toward water resilience enhanced. This output will generate a knowledge product and dissemination material relevant to the services provided to support cross entities' knowledge sharing and capacity building. Dissemination material(s) will include tools and technologies on water resilience and efficiency through digitization. Dissemination modalities may include workshops/seminars/training sessions to promote, among others, learning from the experiences of water service providers and water resource management organizations, use of social media platforms, and production of web-based materials, inter alia, to facilitate wider reach and accessibility beyond the TA duration.

3. Detail of the Tina River Hydropower Development Project

(1) Description

a. History

The Tina River Hydropower development project was first studied in some detail by a World Bank Power Mission in February 2006. During this mission, desk studies were carried out for three developments on the Ngalimbiu, Nuhu and Choha river catchment areas. These desk studies concluded that a major tributary of the Ngalimbui River, the Tina River, appeared to have the best hydropower potential. Based on the results of these desk studies, the Solomon Islands Government (SIG) commissioned a pre-feasibility study of the Tina River hydropower development. The pre-feasibility study, funded by the World Bank commenced in May 2007, and the final report was submitted to the World Bank in November 2007. The prefeasibility study confirmed that the nine kilometre stretch of the Tina River identified by the World Bank mission was the most promising for a staged hydropower development to serve Honiara and other prospective loads in the area.

Following on from the pre-feasibility study, a full feasibility study into the Tina River Development was carried out. The full feasibility study was to be initially conducted in two phases – phase 1 studied the entire length of the Tina River from the junction with the Mbeambea tributary down to the confluence with the Toni river, with the purpose of determining the optimum scheme for a Stage 1 development. Phase 2 of the study further developed

the outcomes of the Phase 1 study with a view to preparing the optimum scheme for full development. Due to the high risk geological nature of the Phase 2 site, a further Phase 3 was commissioned to find an alternative site featuring less geological risk.

b. Components

The Tina River Hydropower Development Project consist of four components: (i) Hydropower Facility; (ii) access road; (iii) transmission lines; and (iv) Technical Assistant. In terms of timing, the Technical Assistant component is expected to begin first in order to maintain continuity of the Project Office (PO) with the preparation phase and to support the other project components.

- Component 1: Tina River Hydropower Facility. Under a 34-year PPA(including 4-year construction period), the Project Company will develop, finance, construct and operate the HPF with an installed capacity of 15 MW located on the Tina River, 20 km southeast of Honiara, and will comprise of a. (a) A roller-compacted-concrete (RCC) dam 72 m high (from foundation) located in a narrow gorge on the Tina River; (b) A waterway including a 3.3 km headrace tunnel in 3.3 m diameter, surge shaft and a surface type steel penstock in 3.0 m diameter to convey water from the dam to the powerhouse; (c) A powerhouse 5.7 km downstream of the dam site that will house three 5 MW Francis turbines and an extra bay for future installation of a possible fourth 5 MW turbine.
- Component 2: Access Road. The access road to facilitate Hydropower Facility construction and operations includes two lots: Lot 1 involving the upgrade of the existing 13.2 km road from Black Post Junction to Managikiki Village; and Lot 2 involving a 5.5 km "greenfield" road through steep heavily forested terrain from Managikiki Village to the dam and power station.
- Component 3: Transmission Lines. Power to be generated from the HPF will be evacuated to HES through two parallel single-circuit 66 kilovolt (kV) transmission lines of 23 km to the existing Lungga Diesel Power Station
- Component 4: Technical Assistance. This supports the operation of the Project Office under MMERE to finance consultants to monitor overall project implementation, prepare and periodically update a Project Operations Manual in cooperation with the other implementing entities, provide awareness building and training for various stakeholders, monitor and support environmental and social safeguard arrangements and the Gender Action Plan (GAP), implement the Land Acquisition Resettlement Plan for Components 1 and 2, maintain a Dam Safety Advisory Panel (DSAP) and an independent environmental and social monitoring agent, conduct a cumulative impact assessment, liaise with various government counterparts and other stakeholders, support implementation arrangements agreed under the land acquisition process, support communities in utilizing their share of project benefits for community development, and to report to the Bank and other financiers on project performance and achievement of objectives.

(2) Challenges

- Co-financing risk. In addition to IDA, there are five other concessional financiers (ADB, GCF, EDCF, IRENA/AFDF, and APIP TF) each of which has its own processes and timetable for approval and effectiveness.
- Construction risk. Construction of the Hydropower Facility could require extension of time due, in particular,

to adverse geological conditions of the dam foundation and tunnel excavation.

- Social risk. There are still two of the five core land tribes that have not established their cooperative societies to receive compensation payments, despite the fact that the appeals period has ceased, the title to the land is now held by the Commissioner of Lands of SIG, and compensation payments are available in a trust account.
- Environmental risk. The most significant environmental risks during project construction and operation will be the quantity and quality of water in the Tina River for drinking and washing and maintenance of aquatic habitat, and obstruction of fish migration up and downstream.

(3) Solutions

- Co-financing risk. The Bank and SIG are coordinating across donors to align processing schedules since delayed approval of funding sources could cause significant implementation start-up delays. The Bank is also assisting SIG to align the financiers' requirements, conditions and covenants to avoid mismatches which may adversely impact project implementation.
- Construction risk. Project Company will contract an Owner's Engineer responsible for ensuring timely and quality construction as well as safety, while the PC and SIEA will jointly finance an Independent Engineer to validate that the EPC contract is effectively implemented in accordance with the PPA. DSAP will also monitor design and construction and provide expert advice to ensure dam safety.
- Social risk. SIG has taken a range of steps to ensure ongoing alignment of tribal interests in the Project including the provision of royalties, establishment of the proposed TCLC, and establishment of the proposed benefit sharing mechanism.
- Environmental risk. Impacts on terrestrial and aquatic wildlife, in particular, the presence of migratory fish,

above and below the dam, will be monitored through regular Project Company reports, the safeguards experts contracted by MMERE and supported by the Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM). A trap-and-haul system to move fish past the dam will be built during construction and implemented as soon as water begins to be diverted into the powerhouse. Oversight will be provided by MMERE PO and the Independent Environmental and Social Monitoring Agent.

4. Future Plan

The Tina Hydro power Project has been committed to meeting environmental and social management standards, and with the final approval of the Environmental and Social Management Plan in May 2023, construction of the access roads are underway.

And although the project has experienced some delays due to global inflation caused by Covid-19 and the Russian-Ukrainian war, full-scale construction is underway, with the hydropower plant scheduled to be completed in February 2028 and provide power to Honiara, Solomon Islands.

5. References

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The World Bank, Tina River Hydropower Development Project (P161319)

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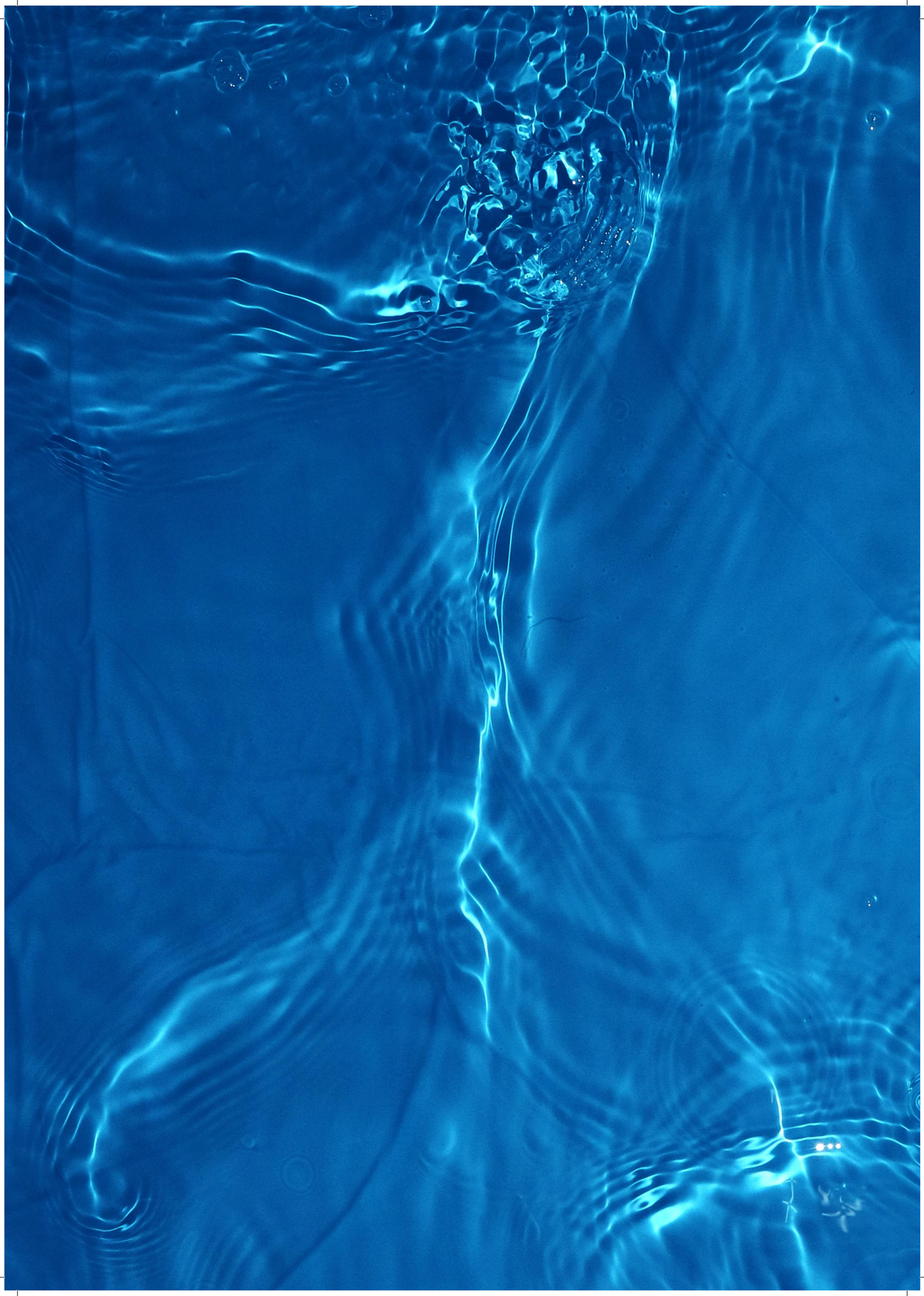

Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

South East Asia

Cambodia

Ministry of Water Resources and Meteorology
(MOWRAM)

1. Introduction

(1) Water Resources of Cambodia

Cambodia is a rich country in water resources, but about 70% of the annual water resources are comprised of water inflow from outside of the country. Most of the water resources pass through the Mekong River, which flows through Cambodia for about 500 km before entering the Mekong Delta and about 86% of Cambodian territory is within the Mekong River Basin, including the catchments of the Bassac River, the Tonle Sap River, and the Great Lake and its tributaries. The river basins in Cambodia can be grouped into five River Basin Groups (RBGs) with 39 river basins based on their hydrological characteristics.

(i) Tonle Sap RBG : It is located in the center of the country with about 45% of the territory, including the Great Lake, and the Tonle Sap River and tributaries.

(ii) Upper Mekong RBG : It is the upper part of the Mekong River, from the border of Cambodia and Laos to 20 km downstream of Kratie. This area is characterized by a braided channel with sand islands and deep-pool fish spawning refuges.

(iii) Mekong Delta RBG : It covers the area from downstream of Kratie to the border of Cambodia and Vietnam. Most of the area is on the Mekong River floodplain, and most rivers are affected by the backwater effects of the Mekong River during the flood season and tidal effects during the dry season.

(iv) Coastal RBG : It is in the southwestern part of the country and is confined by the Gulf of Thailand and the Elephant and Cardamom mountain chain in the northeast.

(v) 3S RBG : It is in the northeastern part of the country and includes the Se Kong, Se San, and Sre Pok rivers draining into the Mekong River at Stung Treng.

(2) Ministry of Water Resources and Meteorology (MOWRAM)

Ministry of Water Resources and Meteorology (MOWRAM) and they are responsible for identifying policy and strategy development of water resources to execute sustainable domestic water resources relating projects in accordance with the political role specified in the Government of Kingdom of Cambodia (GKC). The MOWRAM was independently separated from the Ministry of Agriculture, Forest and Fisheries (MAFF) in 1999 under the Sub-decree 58 and they are implementing the mission of development and management of water resources of the country in an effective, equitable and sustainable manner by integrating river basin water management, water resources management, management of water resources infrastructure and management of water-related hazards such as floods, droughts and so on.

The MOWRMA is composed of 7 technical departments, 3 administrative departments, Technical Service Center for Irrigation and Meteorology (TSC) and 25 Provincial Department of Water Resources and Meteorology (PDWRAM). There are 5 categories in staff qualification for engineer, technician, vocational staff, qualified staff and non-qualified staff. Total number of staff is 882 at central level and 503 at provincial level as of April 2021.

The MOWRAM has responsibilities for monitoring and managing all activities related to water resources and meteorology, and plays a key role in the mitigation of water-related hazards. It has the lead role for the implementation of the Law on Water Resources Management, 2007. Following are MOWRAM/s main duties and responsibilities.

2. Selected Completed Projects

(1) Sala Ta Orn Dam Development Project

a. Description

The northwest area of Cambodia has high rate about agriculture land (31%) and low rate about irrigation rate. So, this area has big possibility to develop irrigation land by expanding irrigation facilities. The Cambodian Government made it to the EDCF (K-Exim Bank) Rolling Plan with the Sala Ta Orn dam development project as water resource development at northwest area. And then feasibility study, Loan Agreement, detailed design, and construction were progressed as scheduled plan. The project was completed on September 2021. This project has one concrete gravity dam and four canals with 17.7km of total length.
Details were explained at detail of the project.

b. Challenges

Cambodia is considered as an agricultural country due to its wide plain and subtropical climate. Over 70% of population work at agriculture. So Cambodia should put significant effort to the management of water resources. However, due to non-systemic management and shortage of investment, annual flooding causes tremendous property & human life damage. Serious droughts during the dry season result in water shortage, making agricultural productivity decreased. In agricultural country, those reasons are important factors for interrupting economic development. For economic development, solving the problems are necessary.

c. Solutions

The Cambodian government laid great emphasis on the development of water resources through National Strategic Development Plan (NSDP). Under supporting technical support in Korean government, Cambodian government actively promoted water resource project.
For solving economic loss and human life damage due to shortage of water resources and frequent flood, Cambodian government requested the project support to Korean government at March 2012.
Feasibility Study report was prepared to EDCF at November, 2012. After announcement of Loan Agreement at August 2013, processing of consultant selection, contractor selection and construction were progressed in sequence. Finally, the project was completed on September 2021.

(2) Mongkol Borey Dam Development

a. Description

The implementation of this Project has continued to be reviewed since 1961 when the "Comprehensive Reconnaissance Report on the Major Tributaries of the Lower Mekong Basin" (1961, OTCA) was prepared as part of an effort to exploit irrigation water resources in Mongkol Borey by the Japanese Government. In the "Master Plan of Water Resources Development in Cambodia" (2008, K-water), the Project was selected as one of priority development projects, when Korea Exim Bank carried out the F/S for the Project in August, 2009.
Based on the results & findings of the said F/S (August, 2009), the Cambodia Government requested Korean Government for credits, which would be used to implement the Project, and Korean Government selected to

grant credits to Cambodia in December, 2010. And then feasibility study, Loan Agreement, detailed design, and construction were progressed as scheduled plan. Finally, the project was completed on August 2015. The project has one concrete regulator dam (Ta Haen) in Mongkol Borey river and 13.9 km connection channel between Ta Haen dam and existing Kamping Puoy reservoir.

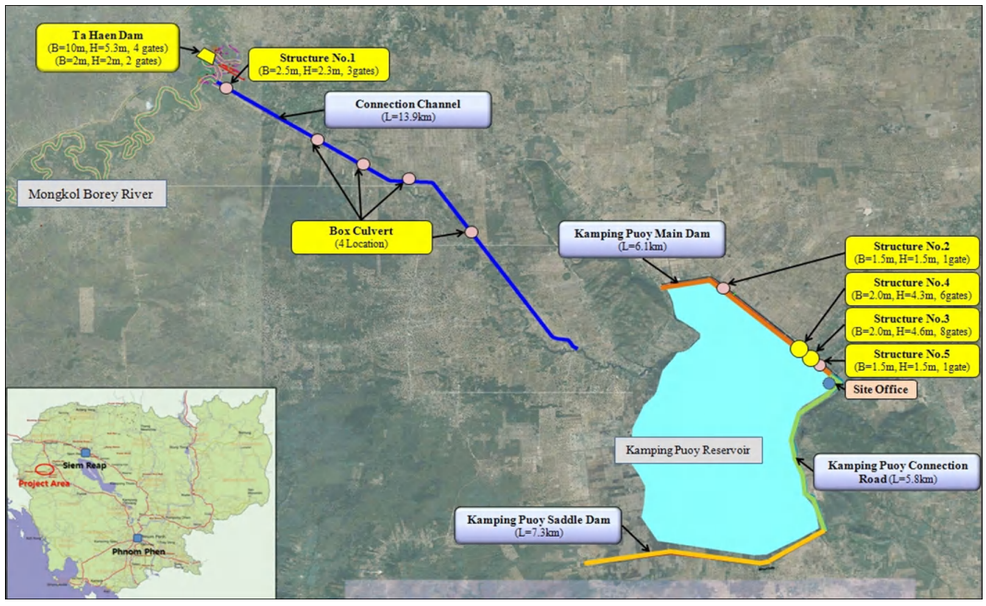

Figure 2.1 Location map of Mongkol Borey Dam Project

Figure 2.2 Ta Haen Dam Picture (Left: Before, Right: After)

b. Challenges

The structure has been fully utilized to supply the irrigation water to the existing Kamping Puoy reservoir as purposed. But currently due to the no-storage dam in upstream river, during every dry season, the river results in water shortage during few months. Moreover, one more irrigation scheme at downstream is preparing currently, this shortage of this river shall be solved.

c. Solutions

In order to solve the water shortage of main river during dry season, additional upstream storage dams are necessary to capture the flooding water during rainy season. So MOWRAM seeks the fund to erect the new dam/reservoir at upstream under cooperation with Korean Government.

(3) Krang Ponely Water Resources Development Project

a. Description

In Krang Ponely River, the existing dams and irrigation systems currently supplied water to the area of 8,000 ha, but most of the structures were deteriorated, and not properly operated. Hence rehabilitation and new construction of the structures were urgently needed for stable and efficient supply of water and electricity.

The objectives of Krang Ponley Water Resources Development Project are to secure water supply for improvement of agricultural, industrial and domestic condition, to reduce flood damages and to supply hydroelectric power in the downstream areas of the Krang Ponley River Basin by means of reinforcing the hydraulic functions of the existing facilities both upstream and downstream of the reservoirs through rehabilitation and new construction.

This project has three dam rehabilitation, two canals with length 4.3km, and seven hydraulic structures and two micro hydro-electric power plants. The project was completed on February 2012.

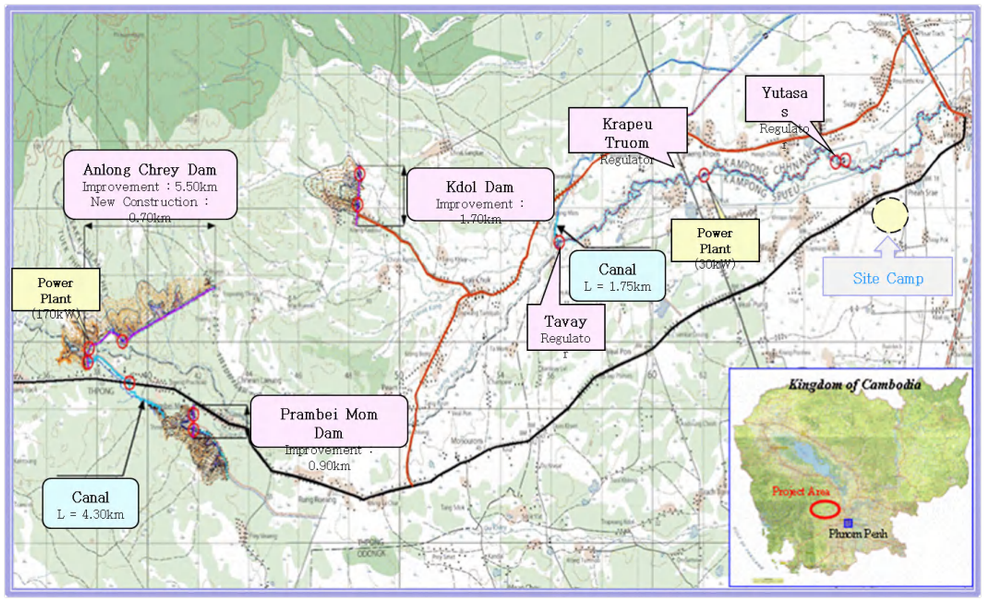

Figure 2.3 Location map of Krang Ponely WRDP

Figure 2.4 Anlong Chrey Dam Picture (Left: Before, Right: After)

b. Challenges

The structure has been fully utilized to supply the irrigation water to the downstream area. Since the completion of the project, more than twelve years have been passed. So detailed diagnosis for all structures is necessary and overall evaluation for the project shall be carried out for the sustainable maintenance and for establishment of upgrading/rehabilitation plan.

c. Solutions

Within five to ten years, MOWRAM will seek the fund for detailed diagnosis for all structures and overall evaluation for the project. And then according to the result of diagnosis and evaluation, next step will be determined.

3. Detail of the "Sala Ta Orn Dam Development Project"

(1) Description

History of the Project

The northwest area of Cambodia has high rate about agriculture land (31%) and low rate about irrigation rate. So, this area has big possibility to develop irrigation land by expanding irrigation facilities.

The Cambodian Government made it to the EDCF Rolling Plan the Sala Ta Orn dam development project as water resource development at northwest area. Feasibility Study report was prepared to EDCF at November, 2012. After announcement of Loan Agreement at August 2013, processing of consultant selection, contractor selection and construction were progressed in sequence.

Location and Specification of Project

The project area, Battambang Province, area is 11,702 and its rate is one sixteenth of total area of Cambodia. Main river at project area is Sangke River.

Project area is located at Central market of Battambang province to Tonle Sap Lake down about 6.2km. Project location is as follows.

Figure 3.1 Location map of Sala Ta Orn Dam

Project specifications are as follows.

Basin

- ☐ River name : Sangke River
- ☐ Bain area : 3,251km^2
- ☐ Annual precipitation : 1,317mm
- ☐ Annual inflow : 1,836 Mil.m^3

Reservoir

- ☐ Maximum water level : EL.13.98m (MWL)
- ☐ Flood water level : EL.13.16m (FWL)
- ☐ Normal high water level : EL.10.50m (NHWL)
- ☐ Low water level : EL. 5.50m (LWL)
- ☐ Total storage : 12.05 Mil.m^3
- ☐ Water supply in reservoir : 154.3 Mil.m^3/year
- ☐ Water Supply Reliability : 91.2% (Wet season: 98.9%, Dry season: 82.1%)

Main Dam

- ☐ Location : Middle-lower Sangke River, near Battambang Province
- ☐ Type : Concrete Gravity Dam
- ☐ Crest level : EL.15.0m
- ☐ Height : 13.0m
- ☐ Length : 74.0m

Diversion Facilities

- ☐ Type of cofferdam : Fill Dam
- ☐ Crest level of cofferdam : EL.13.0m
- ☐ Type of diversion : Open channel
- ☐ Scale of diversion canal : W55.0m×H8.5m×L520.0m
- ☐ Return period for design : A 5-year frequency flood, 726.0m^3/s

Spillway

- ☐ Type : Ogee Spillway with Gate
- ☐ Crest level : EL.5.5m
- ☐ Gate : Roller Gate, W10.0m x H6.0m x 6EA
- ☐ Design flood
  - 50 year return period : 1,203 m^3/s
  - 500 year return period : 1,678 m^3/s
- ☐ Maximum discharge
  - 50 year return period : 1,183 m^3/s
  - 500 year return period : 1,408 m^3/s
- ☐ Type of energy dissipater : Stilling Basin Type-IV, B72.0m x L32.0m

Project Effect

- ☐ Total water supply : 154.3 Mil. m^3
- ☐ Irrigation : 81.1 Mil. m^3(Wet season 43.2 Mil. m^3, Dry season: 37.9 Mil. m^3)
- ☐ Instream flow : 73.2 Mil. m^3
- ☐ Flood control capacity : 5.9 Mil. m^3

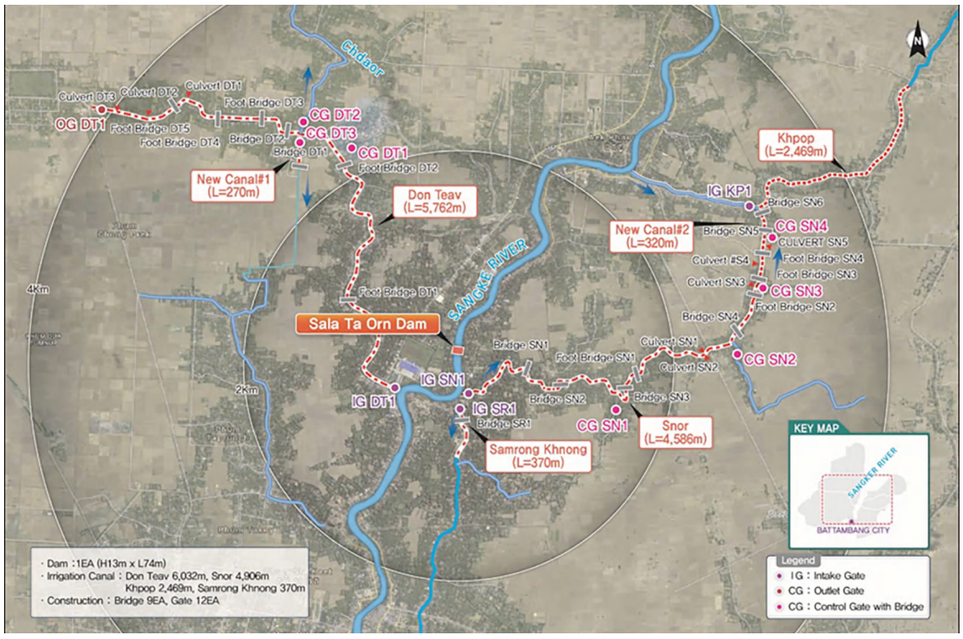

Figure 3.2 Scope of Sala Ta Orn Dam Project

(2) Challenges

Cambodia is considered as an agricultural country due to its wide plain and subtropical climate. Over 70% of population work at agriculture. So Cambodia should put significant effort to the management of water resources. However, due to non-systemic management and shortage of investment, annual flooding causes tremendous property & human life damage. Serious droughts during the dry season result in water shortage, making agricultural productivity decreased. In agricultural country, those reasons are important factors for interrupting economic development. For economic development, solving the problems are necessary.

Battambang province is typical agricultural area located at northwest in Cambodia. But, due to topographic conditions and external factors like back water at Tonle Sap Lake located at downstream, Battambang province is occurred repetitive flood damage. And efficient water resource management is necessary due to shortage of agricultural water result from backward water facilities. Also, project area is located at Central market of Battambang province to Tonle Sap Lake down about 6.2km. So, flood mitigation and increasing of irrigation efficiency is necessary using dam construction and repairing of irrigation canal.

During initial construction stage, resettlement issue was a challenge which was difficult to completed in short time. During construction stage, there was a flood risk to overflow the coffer dam and erosion of coffer dam slope also.

(3) Solutions

The Cambodian government laid great emphasis on the development of water resources through National Strategic Development Plan (NSDP). Under supporting technical support in Korean government, Cambodian government actively promoted water resource project like master plan of water resources development and then requested loan proposal to construct the infra structures.

Cambodian government requests the project support to Korean government at March 2012. For negotiation and sign of loan contract at each government, project is processing by selecting the consultant using aid from EDCF at October 2015.

- 2012. 03 : Loan Request (Cambodia Government → Korea Government)
- 2013. 04 : Conclusion of Loan Contract (Cambodia Government ↔ Korea Government)
- 2015. 10 : Start Detailed Design
- 2018. 01 : Signing of Contract Agreement of construction Work
- 2018. 05 : Commencement of Construction
- 2021. 08 : Completion of Construction

During construction stage, in order to solve the resettlement issue, design change of diversion channel alignment was done from the far side to near side of the dam. And concrete lining for the cofferdam slope was done to protect the erosion.

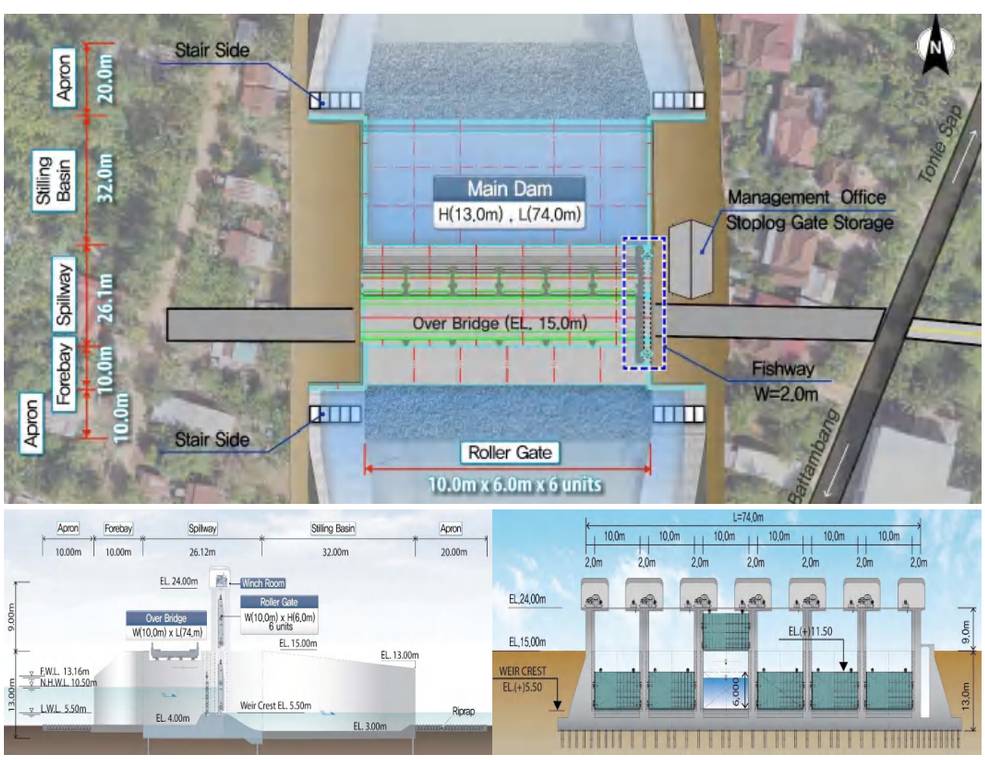

Figure 3.3 General Plan and Section of Sala Ta Orn Dam Project

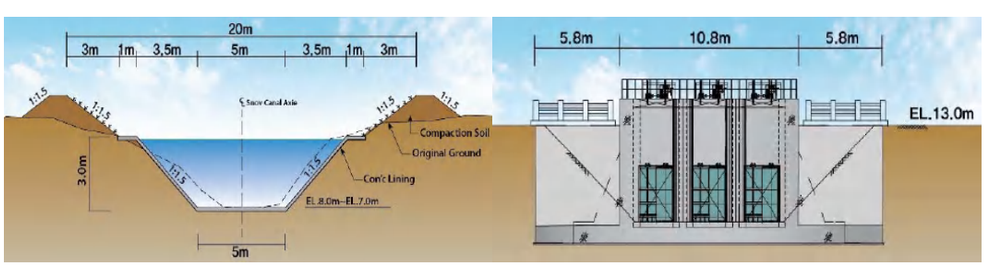

Figure 3.4 General Plan and Section of Canal

Figure 3.5 Picture of Sala Ta Orn Dam (Left: Before, Right: After)

Figure 3.6 Picture of Canal (Left: Before, Right: After)

4. Future Plan

(1) Challenges

There are three dams in Sangke River including Sala Ta Orn Dam which is located at downstream. So integrated dam operation is necessary for the optimization of dam operation to utilize the limited water resources efficiently and to protect the flood damage also.

To properly operate the dams in Sangke River, digitalized operation system is also necessary for not only sole dam operation but also integrated dam operation. For more accurate and correct decision making, management of big-data is also important for digital based operation system.

To expand the water supply to the farmers located far from this structures, expansion of canal is necessary.

Climate change is taking place in this places also such as precipitation patterns, more extreme drought and flood events, etc.

(2) Future Action

To upgrade the operation system and to accept digital base operation system, Cambodia Government is seeking the funds to support IWRM of Sangke river basin.

In order to expand the water supply to the farmers located far from this structures, Cambodia Government will seek the fund to support that project.

Within ten years, the function and capability of Sala Ta Orn Project shall be analyzed and evaluated again. Based on this evaluation, the upgrading work shall be determined.

Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

South East Asia

Indonesia

Ministry of Public Works and Housing
(MPWH)

1. Introduction

(1) Water Resources of Indonesia

Indonesia as the largest archipelago in the world consists of five major islands, namely Sumatra, Java, Kalimantan, Sulawesi, and Papua, as well as other small islands. It is located on the equator between the Pacific and Indian Oceans, and the two continents of Asia and Australia. Indonesia has an area of 1,9 million square kilometers, of which about 6,1 million square kilometers is covered by water.

Indonesia has abundant water resources, with an annual average surface water availability of 2,78 trillion m^3/year, which is not evenly distributed throughout Indonesia. Kalimantan Island has the largest water availability while Java Island with the largest population in Indonesia has a smaller water availability which results in Indonesia experiencing water shortages in some areas during the dry season.

Indonesia is also vulnerable to natural hazards such as earthquakes, volcanic eruptions, landslides and tsunamis, as well as hydrometeorological hazards such as floods and droughts. More severe disasters that have occurred in recent years due to climate change have resulted in excessive rainfall causing extreme flooding that inundated low-lying areas of Indonesia resulting in economic and social losses due to the recurrence of such events.

(2) Integrated Water Resources Management in Indonesia

The principle of water resources management in Indonesia is one river, one plan, one management. Indonesia's water resources are managed within 128 official river basin territories that are classified as transboundary, inter-provincial, national strategic, inter-district, and sub-district which is carried out by the central government, provincial regional governments, and district/city regional governments based on the river authority.

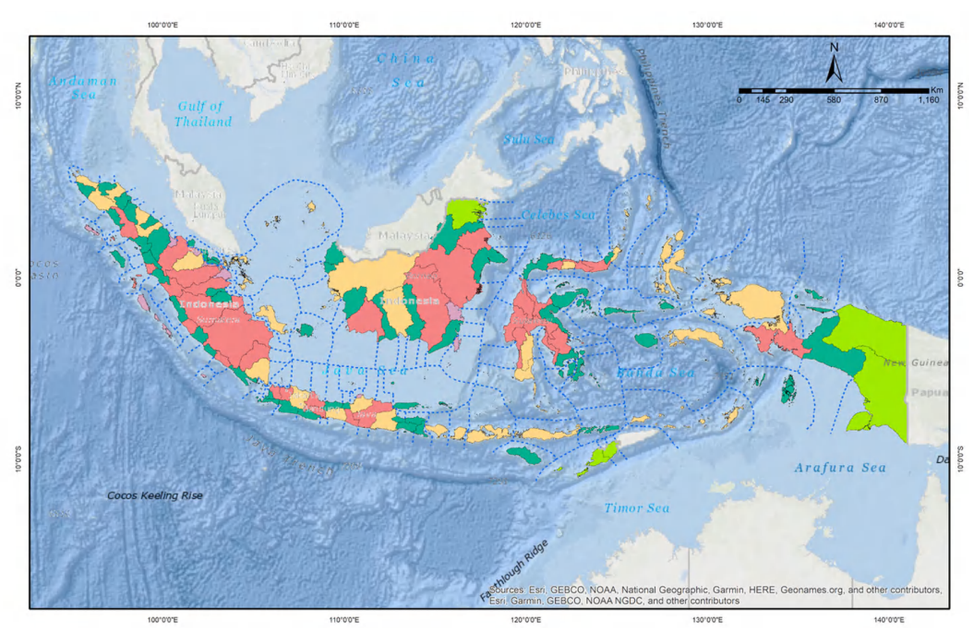

Figure 1.1 Map of Indonesia's River Basin

The implementation of water resources management carried out by the river basin organizations should be done according to the water resources management strategy and masterplan of the river basins. The implementation is including planning, constructing, rehabilitating, and operation and maintenance of water related infrastructures in the basins.

Water resources development in Indonesia based on Water Law No.17/2019 mandates three main activities in water resources management, namely water conservation, water utilization, and water damage control. The Indonesian government is currently emphasizing flood management and dam construction as an effort to conserve water, reduce flooding, provide irrigation water and clean water as well as a source of energy.

(3) Water Resources Infrastructures Development in Indonesia

Ministry of Public Works and Housing has accomplished several water resources infrastructures in Indonesia from 2014-2024 that includes construction of 36 dams, provides 13,57 m^3/s bulk water supply, construction of 205.024 hectares new irrigation area, rehabilitation 1.416.164 hectares existing irrigation area, construction of 155 new small reservoirs, construction of 138 sediment and lava control infrastructures, and construction 671,12 km flood control and coastal protection.

The dam construction is an effort to increase storage capacity to meet the capacity of 120 m^3/capita/year by 2030. By building large dams, Indonesia has been able to progressively expand the utilization of water resources. The number of dams that have been built until 2014 is 229 dams with a total storage capacity of 13,82 billion m^3. Ongoing dam construction over the past 10 years spread across Indonesia totals 61 dams, with an additional 11 new dams. The Indonesian government has successfully completed and inaugurated 36 dams and is working on 25 dams that must be completed and inaugurated by the end of 2024.

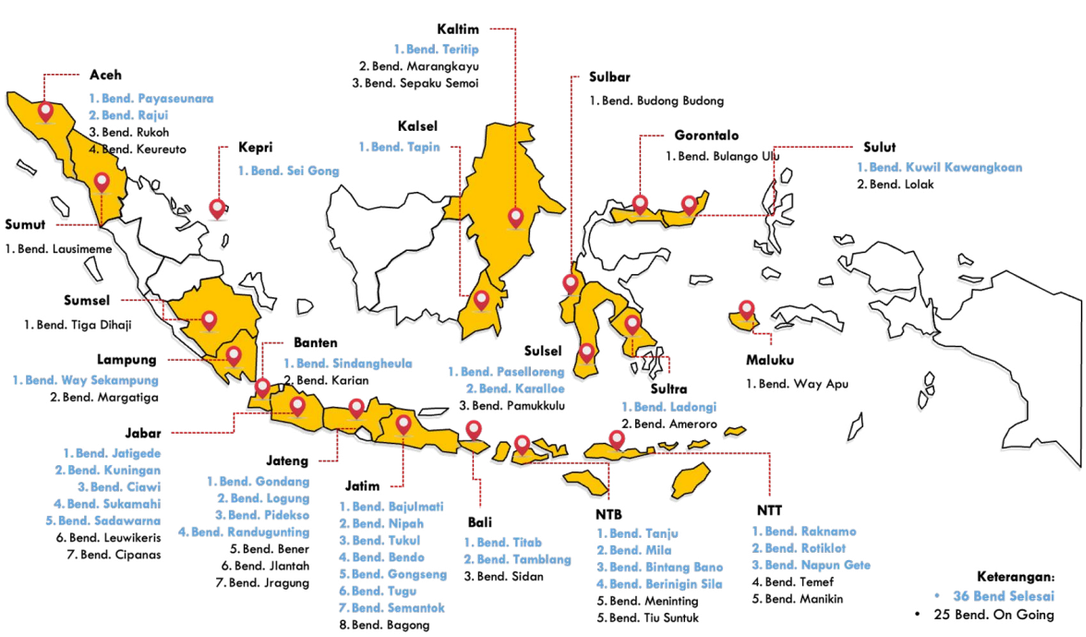

Figure 1.2 Map of 61 Dam Construction in Indonesia (2014-2024)

The construction of the 36 dams has increased the storage capacity to 15,77 billion m^3 and has benefits for the provision of raw water 17,19 m^3/s, irrigation water for 245.103 hectares of irrigation areas, serves as a flood control with a reduced discharge of 6.454 m^3/s, hydroelectric power generation of 143 MW, and solar power generation of 2.293 MW.

2. Selected Completed Projects

(1) National Capital Integrated Coastal Development (NCICD)

a. Description

The National Capital Integrated Coastal Development (NCICD) project includes the construction of sea dikes and river embankments at the river estuaries integrated with polder systems, pumps, collecting channels and sluice gates to protect Jakarta from coastal flooding and sea level rise. The project is divided into 3 phases, namely phase A construction of sea dikes and embankments at the river estuaries, phase B construction of the west side sea wall, and phase C construction of the east side sea wall as shown in the figure 2.1.

The phase A project that has started from 2014 has completed 14,517 km of sea dikes and river embankments at river estuaries, and also 3 retention ponds at Cilincing until 2024.

b. Challenges

NCICD aims to make environmental improvements that include the provision of safe water supply, improved water quality in the estuary, and flood control in DKI Jakarta.

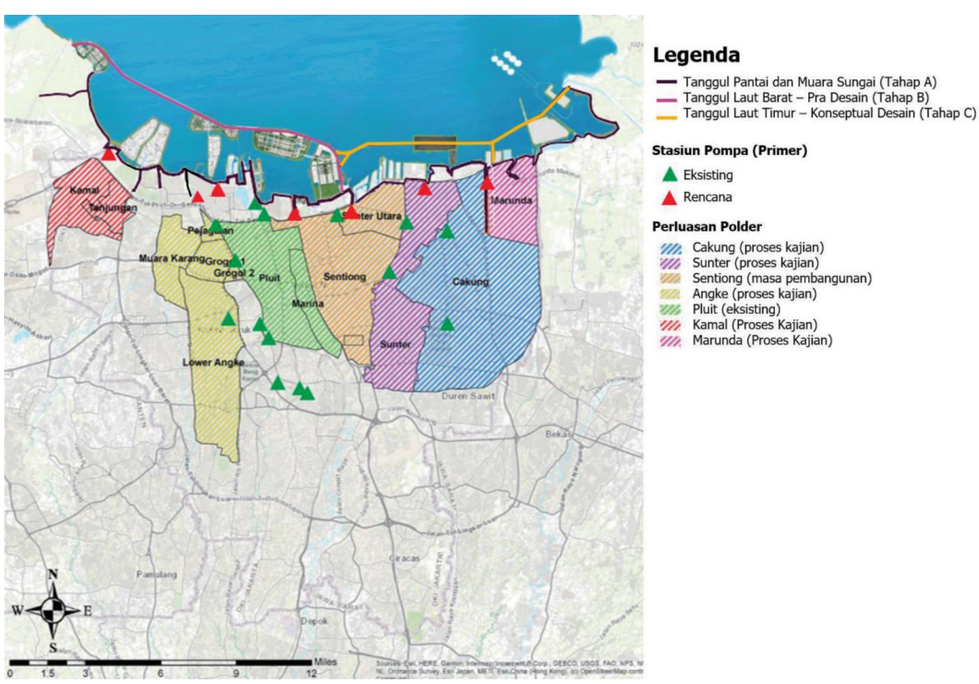

Figure 2.1 Layout of Sea Dikes and Embankments at Jakarta Coastal Areas

c. Solutions

- Integrated flood management;
- Provision of safe water supply and land subsidence control;
- Water quality improvement;
- Integrated city development;
- Sea dike phase A phase integrated with the polder system;
- Sea dike stage B with a 1:10,000-year scale flood safety standard.

(2) Karian Dam Construction Project

a. Description

Karian Dam, located in Lebak Regency, Banten Province with a reservoir area of 1.740 ha, has a storage capacity of 314,7 million cubic meters of water. This dam functions as a multipurpose dam that is projected to reduce 30% of flooding in the downstream area which is a strategic area (Jakarta-Merak toll road and Banten Industrial Estate), supply clean water for 5 million people around Banten Province and DKI Jakarta (Cilegon City, Serang Regency, Tanggerang City, Tanggerang Regency, South Tanggerang City and DKI Jakarta), supply irrigation water for the Ciujung irrigation area covering 22.000 ha, produce a micro hydro power plant of 1,8 MW, and water tourism.

The construction of the Karian dam, which began in October 2015, was inaugurated in January 2024 by the President of Republic Indonesia. The next step and remaining challenge are how to implement the construction of the Karian-Serpong Conveyance System and Karian intake to utilize the water from the reservoir to overcome water shortage in the area.

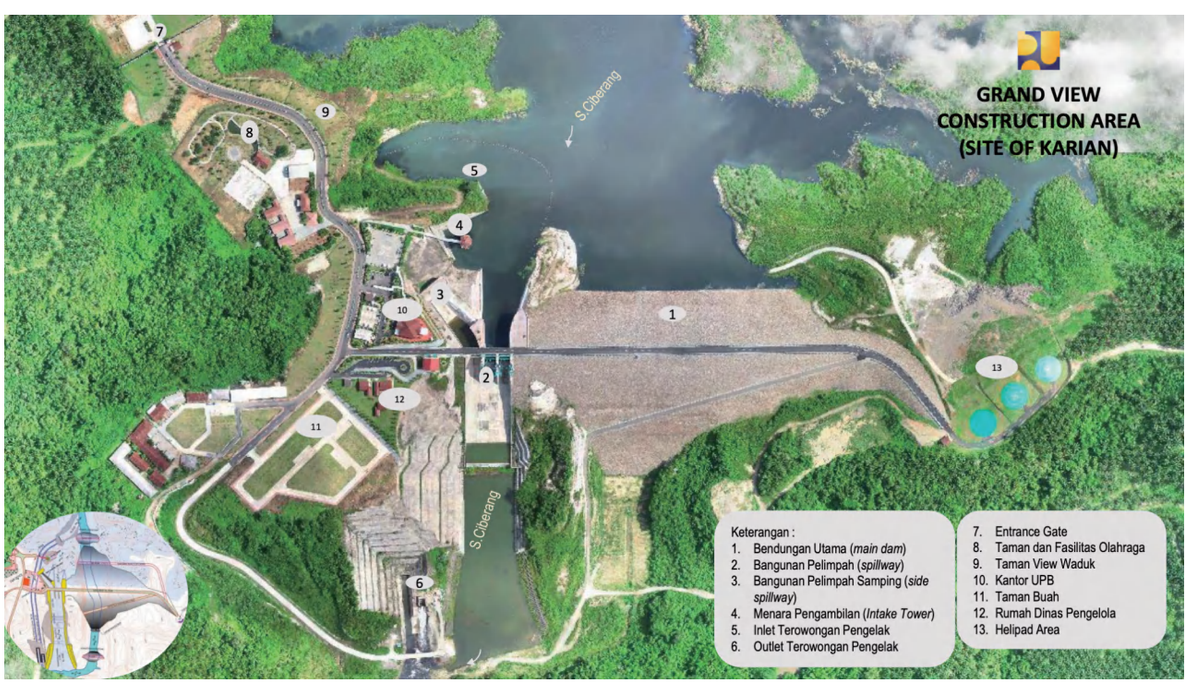

Figure 2.2 Grand View of Karian Dam Construction Project

b. Challenges

The provision of clean water through the conveyance system using pipeline from the dam to the Banten Province and DKI Jakarta is constrained by land acquisition problems.

c. Solutions

After the completion of the Karian dam, the utilization of the dam for clean water supply needs to be carried out through the Karian intake and Karian-Serpong Conveyance System.

(3) Irrigation Modernization of Rentang Irrigation Area

a. Description

Rentang Irrigation Area located in the Cimanuk River Basin at West Java Province that receives irrigation water from Jatigede dam needs modernization of its management and irrigation services to support Indonesia's food security. The objectives of the modernization of irrigation system are for a cost-efficient, demand-oriented, effective and sustainable delivery of irrigation services. It covers an irrigation area of 87.840 hectares covering Indramayu Regency, Majalengka Regency and Cirebon Regency.

The project includes the upgrading and rehabilitating irrigation systems that will improve the capacity of their main canals, namely Sindupraja from 37 to 74 m^3/s and Cipelang from 26 to 56 m^3/s. It also covers the performance improvement of existing headworks and its facilities, upgrading 73 km of main canals, rehabilitating 169 km of secondary canals, 703 km of tertiary canals, and 446 km of drainage canals.

The project that has started from 2016 has now completed 53% rehabilitation/upgrading of the main canals, 74% of secondary canals, 49% rehabilitation of drainage canals and 57% rehabilitation of waterworks.

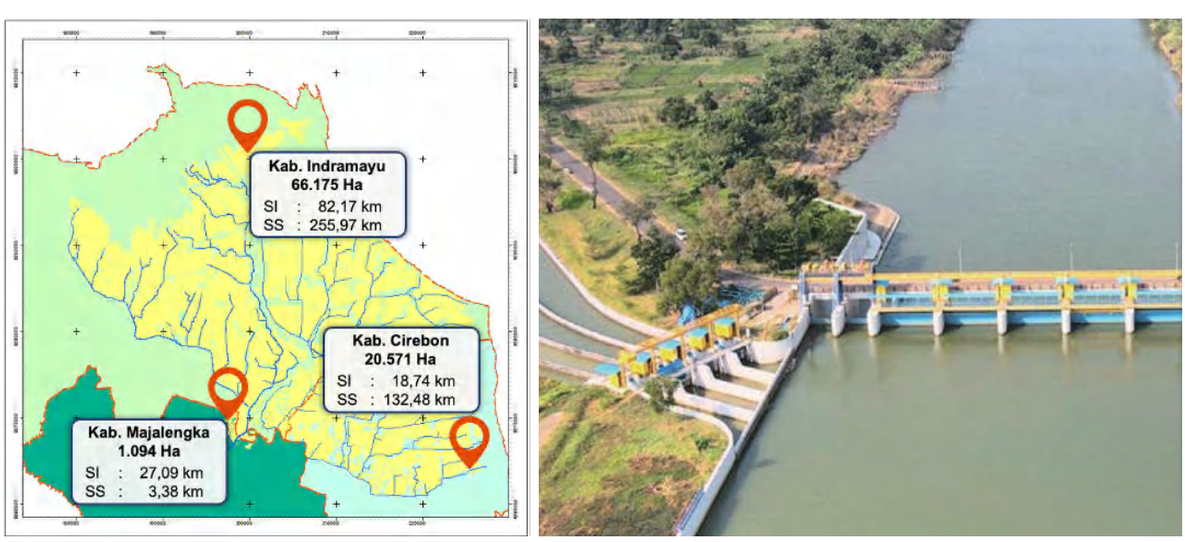

Figure 2.3 Rentang Irrigation Area Project

b. Challenges

Improvement of irrigation water services at Rentang Irrigation Area that includes the water adequacy, reliability, fairness and speed of service.

c. Solutions

- Establish Modern Irrigation Management Unit by 2025;
- Strengthening and empowering the Modern Irrigation Management Unit, Irrigation Commission, and P3A/GP3A/IP3A;
- on-Demand Irrigation Operation;
- Real time monitoring and control irrigation operation for water resource utilization.

(4) Flood Forecasting and Warning System in the Citarum River Basin

a. Description

Expansion of Flood Forecasting and Warning System in the Citarum River Basin is expected to improve the Integrated Flood Management in the basin by enhancing the floods response, disaster preparedness resilience, and sustainable development in response to floods. The project is carried out by installing hydrological stations and setting up the hydrological models to improve water resources planning, management and decision system.

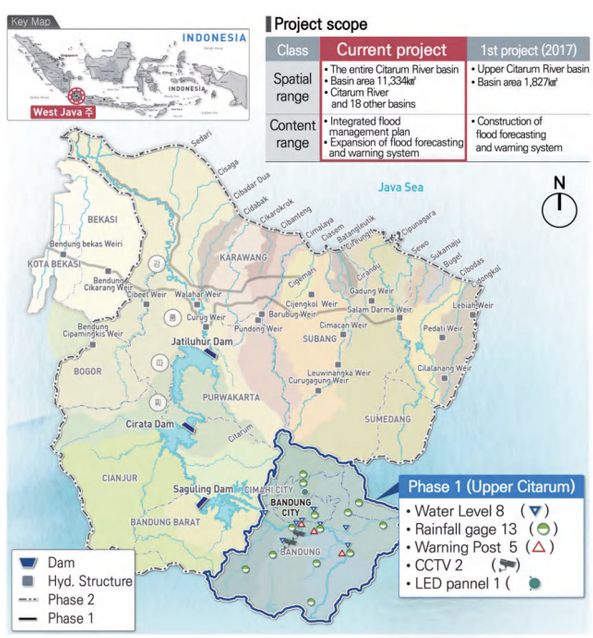

Figure 2.4 Map of Flood Early Warning System Project at Citarum River Basin

b. Challenges

Insufficient of water resources information and hydrological analysis for sustainable water resources planning & management due to the lack of hydrological stations and flood forecasting and early warning systems in the basin and data sharing of water resources information with stakeholders.

c. Solutions

- Improving the management of hydrological stations and maintaining the equipment;
- Conducting capacity building for IT staffs that operate the system, and reliable data acquisition (setup of standardized hydrological monitoring network) and data sharing with other stakeholders.

(5) Information and Communication Technology - Flores

a. Description

Advanced ICT-base hydrologic measurement in West Flores Island is expected to improve the efficient water resources management, enhancing the quality of life through balanced regional economic growth and strategic expansion to other districts, river basins and islands.

b. Challenges

Difficulty to distinguish missing data due to mixed problem of 'no record data' and 'missing data.

c. Solutions

- Capacity building for reliable data acquisition (setup of standardized hydrological monitoring network);
- Sound and implementable technology application (to overcome too much, too little, and too dirty water problems at the river basin level);
- Human resources training and education.

3. Detail of the "Karian Dam Construction Project"

(1) Description

Background

The Banten Province and DKI Jakarta is experiencing a clean water shortage especially to fulfill households, urban and industrial needs. Population growth that leads to urban development and increasing of industrial estate over the last few decades, resulting an increase of water demand quite significantly. The environmental degradation has also contributed to the decline in the availability of both quality and quantity of clean water.

Flood disasters have also become a serious problem for Banten Province, especially in Lebak Regency, where the inundated areas are in six sub-districts, namely Cipanas, Lebakgedong, Sajira, Curugbitung, Maja and Cimarga. Lebak Regency is also prone to drought when the dry season arrives, especially the threat of crop failure in rice fields.

The clean water crisis and flood disaster need to be addressed immediately to avoid a more severe clean water shortage and recurring flood disasters.

Project Information

The Karian dam that impounds the Ciberang River located at Tanjung Village, Rangkasbitung, Lebak Regency has a capacity of 314,7 million cubic meters. This dam is projected to minimize the flooding by 30 percent for downstream areas which are strategic areas with important infrastructure such as the Jakarta-Merak Toll Road and integrated industrial areas in Banten.

The Karian dam is also projected to overcome the clean water crisis for 5 million people by providing 13,9 m^3/s of bulk water supply for the Banten Province and DKI Jakarta. The construction of the Karian-Serpong Conveyance System (KSCS) can supply 9,1 m^3/s bulk water supply for Lebak Regency, Tangerang City, Tangerang Regency, South Tangerang City, and DKI Jakarta. Meanwhile, the needs of 5,5 m^3/s bulk water supply for Cilegon City and Serang Regency will be fulfilled through Karian intake.

The Karian Dam can also support national food security by providing irrigation water for 22,000 hectares of DI Ciujung which is prone to drought. In that way, the regional economic growth in the agricultural sector will increase. The dam also has potential energy for PLTMH of 1,8 MW and can support water tourism in the area.

With a budget of IDR 1.2 trillion from the South Korean Government for construction and IDR 800 billion from the State Asset Management Institute for land acquisition, the construction of the Karian dam, which began

Figure 3.1 The Karian Dam Project

in October 2015, was inaugurated in January 2024 by the President of Republic Indonesia. The next step and remaining challenge is how to implement the construction of the Karian-Serpong Conveyance System (KSCS) and Karian intake as soon as possible to utilize the water from the reservoir to cope clean water shortage in the area.

(2) Challenges

After the construction of the Karian dam is finished, the challenges are how to follow through the utilization of water resources especially for clean water by providing raw water supply through the construction of Karian-Serpong Conveyance System (KSCS) and Karian intake. The difficulty will be on the land acquisition and construction of the conveyance system through pipe from the dam to the targeted areas.

(3) Solutions

After the completion of the Karian dam and once operation has started, the benefits for water supply will be perceived by implementing the construction of Karian-Serpong Conveyance System (KSCS) and Karian intake.
The benefits of flood control and irrigation water needs can be achieved by optimizing the operation of the dam according to the reservoir operation curve in order to regulate river inflow and outflow to the reservoir accordingly. Increment of reservoir inflow that is estimated as major inflow magnitude of the system, should be maintained to keep the water level of the reservoir as formulated as the operation pattern in term of flood managements. It means that the dam should discharge the water properly through the outlet system of the dams.
Furthermore, this dam has the potential to be developed as a tourist attraction. It is hoped that the existence of this dam will be able to contribute to improving the economy and development of Lebak Regency.

4. Future Plan

(1) Global Challenges

Indonesia has a high risk of geological and hydrometeorological disasters because Indonesia is located on the Pacific Ring of Fire, with 127 active volcanoes and the meeting of three earth plates, and has a high average rainfall intensity of >2,000 mm/year. In addition, environmental quality in many catchment areas has decreased due to human activities characterized by a reduced ratio of green land cover, increased sedimentation rates, and increased maximum and minimum discharge ratios. These ecosystem and land use changes ultimately alter the water balance in the catchment and the level of disaster vulnerability.

It is necessary to develop infrastructure that is resilient to disasters and climate change to reduce hydrometeorological disasters. Disaster Risk Reduction must be implemented correctly in the normal, pre-disaster, post-disaster, and recovery stages, by doing the following things.

1. re-analyzed infrastructure design and updated existing standards;
2. implement sustainable disaster resilience for all stakeholders;
3. accelerating the development of disaster management infrastructure;
4. increase public awareness in in preventing and reducing disaster risks.

(2) Future Action

The Indonesian government is preparing a long-term development plan (20-year plan) towards Indonesia Emas 2045, with the vision of becoming a sovereign, advanced and sustainable archipelago. There are 5 transformative efforts that will be implemented to achieve this vision, namely:

1. Managing demand and supply to ensure the water balance in watersheds is not in deficit, critical or stressed.
2. Increase water storage capacity to 200 m^3/capita.
3. To rebalance the nexus (increase demand for irrigation, demand for energy and decrease water stress)
4. Apply water accounting principles for environmental conservation aspects of the water cycle.
5. Integrate structural and non-structural approaches to improve the resilience of urban areas to flooding.

In line with the long-term development plan, in the medium-term phase I (2025-2029), Indonesia will begin to pursue several measures, such as:

1. Restoring effective storage and increasing the capacity of some existing dams, for example through dam repairs and the use of technology.
2. Rehabilitate and revitalize several other dams and reservoirs, including natural reservoirs, such as lakes and ponds.
3. Continue several ongoing dam constructions, namely Karangnongko, Cibeet, Cijurey, Cabean, Pelosika, Jenelata, and Riam Kiwa.
4. Initiate the construction of new dams by considering technical and social readiness.
5. Operate existing dams by considering the safety and sustainability aspects.

Achieving these goals requires a lot of resources, especially an adequate and appropriate budget. In the future, the role of the private sector and other alternative financing needs to be increased, so that dependence on the state budget will gradually decrease.

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Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

South East Asia

Lao PDR

Dept. of Water Resources of
the Ministry of Natural Resource and Environment
(MONRE)

1. Introduction

(1) Current Status of Water Resources in Laos

Laos, with its abundant water resources, stands as a pivotal player in the regional water dynamics of Southeast Asia. Characterized by a rich hydrological landscape, the nation experiences an average annual rainfall of 1,900mm or more, translating to over 462 km^3 of water. However, the distribution of this resource is highly seasonal, with 80% of surface water availability occurring during the monsoon season, leaving only 20% accessible during the dry season. A significant portion, approximately 35%, of the total discharge of the Mekong River originates within the borders of Laos. Flowing through 1,898 km of Laotian terrain, the Mekong River sustains an average annual flow of around 8,500 m^3/s. The total available surface water resource, including the flow of the Mekong River and its tributaries, stands at an annual per capita of 55,000 m^3, the highest in Asia. Despite this abundance, only a tiny fraction of the country's surface water resources have been tapped, with water supply systems covering just 3% of the annual surface runoff.

The utilization of water resources in Laos plays a critical role in various sectors of the national economy, including irrigation, urban and rural water supply, fisheries, tourism, mining, industry, and transportation. Currently, the majority of water usage is allocated to the agricultural sector, encompassing irrigation, fisheries, and livestock farming. Water used for hydropower generation accounts for a mere 5% of the total capacity, equivalent to 23,000 MW. The availability of water resources facilitates favourable conditions for transportation during the wet season, ensuring access to clean water for 60% of the urban population and 50% of the rural population. However, challenges persist, as demonstrated by the increasing demands for water resources to fuel socio-economic development, potentially leading to water scarcity and consequent impacts on future water quality, human health, and the environment. Moreover, natural disasters such as floods and droughts are expected to exacerbate due to climate change, necessitating enhanced capacities and responsibilities in water resource management organizations.

2. Selected Completed Projects

(1) Urban Flood Prevention Project in Vientiane City Vulnerable Area Based on Climate Resilience Model Feasibility Study

Conducted a feasibility study for the Urban Flood Prevention Project in Vientiane City Vulnerable Area based on the Climate Resilience Model. The objectives were

- To strengthen the climate and disaster resilience of vulnerable communities and societies in Laos through an integrated approach to improved risk and vulnerability assessment, planning, and project development.
- To establish sustainable disaster risk management capabilities, particularly in flood and drought risk management.
- To meet relevant SDG Targets: 6 (Clean Water and Sanitation), 13 (Climate Action)

(2) LAOS Vientiane Namsouang Reservoir Renewable Energy (FPV) Project Feasibility Study

Conducted a feasibility study for the LAOS Vientiane Namsouang Reservoir Renewable Energy (FPV) Project. The objectives were:

- To produce clean energy using solar power and supply it to the people of Laos, aiming to enhance their quality of life.
- To utilize shared water surfaces (reservoirs), ensuring scalability through job creation and expansion of the tourism industry.
- To meet SDGs 7 (Affordable and Clean Energy), 8 (Decent Work and Economic Growth), 9 (Industry, Innovation, and Infrastructure), 13 (Climate Action), and 15 (Life on Land)

3. Details of the Selected Completed Projects

(1) Urban Flood Prevention Project in Vientiane City Vulnerable Area Based on Climate Resilience Model Feasibility Study

a. Analysis of Vietiane City's Flood Situation

- Flood Damage in Vietiance

In August 2022, heavy rainfall caused flooding in Vientiane City, primarily affecting the areas surrounding Wattay Airport, the National Convention Center, and the central part of the Naxathong District due to rising water levels in adjacent rivers and canals.

Figure 3.1 Flood Situation around Vientiane City

- Rainfall Analysis

Observation stations and rainfall data

There are three hydrological observation stations within the Mekong River basin and nearby: one at Wattay Airport within the basin, one at Vientiane KM4 (Laos), and one at Nong Khai (Thailand).

Automatic rainfall data from the Vientiane KM4 observation station have been available for 15-minute intervals since May 2010 and daily rainfall data since December 2005. Manual observations (1-6 times/day) were available from 1920 to 2018.

- Design criteria determination

To establish drainage improvement measures for Vientiane City's major flood-prone areas, design criteria for forced drainage facilities (pumping stations) were set on various design standards, upper-level plans, and related plans.

b. Project Objectives and Achievements

- Objectives
  - Collect and manage relevant data to establish efficient and rational water resource management plans.
  - Provision of primary risk management data for climate change adaptation.
  - Contribution to national and regional economic development through the integration of existing facilities and infrastructure expansion.
  - Establishment of sustainable flood risk management capacity (flood forecasting modeling).
  - Realization of SDG-related goals: Clean Water and Sanitation (Goal 6), Climate Action (Goal 13).
- Achievements
  - Infrastructure construction is aimed at ensuring the safety of citizens in flood-prone areas of Vientiane City by establishing an effective drainage system.
  - Enhancement of climate adaptation resilience in flood-prone areas of Vientiane City through the establishment of an optimal water resource management system, particularly mitigating flood damage in disaster-prone urban areas.
  - Provision of sustainable water resource data and knowledge-sharing services.
  - Application of an integrated water resource management system coordinated with existing systems.
  - Establishment of an integrated water resource management system through close cooperation with stakeholders.

c. Project Tasks

- Watershed Survey
  - General status of the watershed and its characteristics, including geology, soil, land use, river facilities, historical flood and drought damage records, and river usage.
  - Water resource characteristics: Meteorological conditions, hydrological conditions, river water usage status such as tap water.
  - Relevant plans: Water resource-related organizations, Water resource-related laws and policies, Urban and rural water supply plans, Water resource management information system plans, Various other development plans

• Hydrological Analysis

Conducted urban flood prediction for vulnerable areas of Vientiane City and developed flood prediction modelling.

• Development of Climate Change Response Master Plan

- Development of an integrated water resource management system for climate change response.
- Outline flood and drought response plans.
- Basic planning for water resource management systems.

(2) LAOS Vientiane Namsouang Reservoir Renewable Energy (FPV) Project Preliminary Feasibility Study

a. Analysis of Laos's Power Situation

Laos exports electricity to Thailand, Vietnam, and Cambodia but imports some electricity from Thailand, China, and Vietnam, making it a net electricity exporter.

The Laotian government plans to construct 183 power plants by 2030, with a total capacity of 26,791 MW and an annual output of 99,470 GWh.

To maximize the utilization of water resources in Laos, there will be introduction of a solar photovoltaic (PV) system combined with hydropower plants in Laos to reduce costs through the shared use of existing hydropower plant transmission facilities and grids.

• Water resource utilization plan in Laos

By introducing a floating solar power generation system linked to a hydroelectric power plant with a reservoir in Laos, costs can be reduced by sharing the hydroelectric power plant's existing transmission facilities and transmission network.

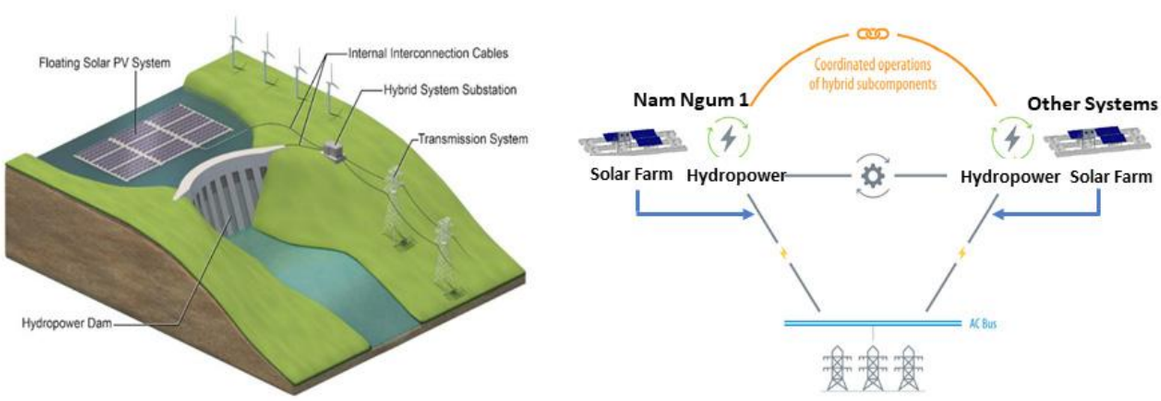


Figure 3.2 Nam Shuang Reservoir hydroelectric power linked solar power generation system concept diagram

- Improving the intermittency of floating solar power generation facilities contributes to base supply or planned transmission. In the case of hydroelectric power plants, increasing base supply during dry periods and securing peak response flexibility can thereby improve planned power generation capacity, flexibility, reliability, and elasticity.

- Water conservation in preparation for the dry season (adjusting power generation capacity according to reservoir or hydroelectric power generation conditions, considering water demand)
- Avoid environmental damage and social impact compared to other power generation sources such as coal-fired power

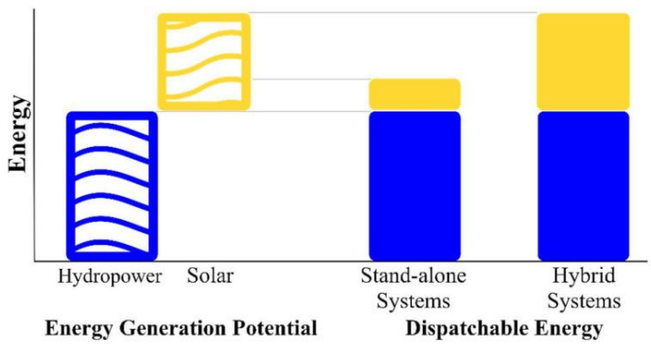


Figure 3.3 Effect of increasing planned transmission of floating solar power generation system linked to hydroelectric power generation

- During the dry season, we secure the flexibility of hydroelectric power generation resources by reducing dependence on hydroelectric power generation and actively utilizing solar power resources. During the rainy season, we actively utilize hydroelectric power generation to reduce dependence on solar power resources, complementing asynchronous seasonal resources. Use in relationships
- From a daily or hourly perspective, solar resources can only be used at certain times of the day, so water power is used to supplement the intermittent output of solar power, and water resources are conserved until times when solar power is unavailable.
- Respond to demand volatility using hydroelectric power to compensate for the hourly variability in solar resource availability.
- Not only does it increase the power generation production of existing reservoirs, but it also suppresses water evaporation in solar modules installed on the water surface, suppressing the decline in water levels during dry seasons, thereby saving water for power generation and increasing water supply, and increasing power production as water levels rise. Operational convenience, safety and reliability improvement

- **Review of Laos grid connection conditions**

Laos cannot export produced power due to a lack of transmission and distribution network facilities, so investment in transmission and distribution network networks is needed to expand power exports to neighboring countries.

- As of 2017, out of the total length of transmission lines (57,897km), the lengths of 115kV and 230kV transmission lines suitable for large-scale power generation industry are only 6,422km and 1,619km, respectively.

- **Establishment of floating solar power plant facility scale**

The total area of Namshuang Reservoir is approximately 11km^2, occupying 10% of the water surface area, and

installation capacity of up to approximately 45MW is possible.

- As a pilot project for floating solar power in Namshuang Reservoir, a 4MW scale 1MW
- Once the efficiency, stability, and economic feasibility of floating solar power are confirmed through the 4MW pilot project, the plan is to expand it to 40MW (approximately 0.97km², occupying approximately 8.8% of the water surface of Namsuang Reservoir) in the future.
- The detailed installation location will be confirmed through a feasibility study and considered for road accessibility, securing sufficient water depth, and the status of fishing activities.

• Floating solar power plant grid connection plan

As there are utility poles within 200m of the expected project site, we plan to use a 22kV line to connect to the Laos national power grid or a distribution line to supply power to nearby residents.
Establishing a detailed grid connection plan after confirming the capacity that can be connected to utility poles through a feasibility study and reviewing the technology to determine whether a connection is possible is necessary.

Project Objectives and Achievements

• Objectives:

Production of clean energy using solar energy and supply to Laotian citizens to enhance their quality of life.
There are expectations of job creation and expansion of the tourism industry through the use of shared reservoirs (reservoirs) for installation.

• Achievements:

Achievement 1: Establishment of a local network to promote the Namsouang Reservoir solar PV plant demonstration project and collect primary data for its construction.
Achievement 2: Confirmation of legal and regulatory conditions for promoting solar PV projects through the establishment of a network with officials responsible for managing energy projects in Laos, MEM, and EDL.
Achievement 3: Basic planning for the installation of a solar PV plant in the Namsouang Reservoir through on-site surveys, confirmation of accessibility, including access roads for construction, and collection of weather data for the establishment of a PVsyst simulation.
These completed projects mark significant milestones in addressing Laos's water management and renewable energy challenges, contributing to both environmental sustainability and economic development.

4. Future Plan

Building upon the preliminary feasibility studies completed earlier, plans are underway to initiate actual projects based on the findings. Additionally, new projects are intended to commence in 2024.

(1) New Project: Drought Risk Assessment and Sustainable Water Utilization in Affected Province of Lao PDR

This project aims to provide resilient and sustainable water management systems to Savannakhet province, Laos communities. Employing a phased approach, it comprehensively addresses various aspects of water security to enhance drought resilience and management.

The project will yield three key outcomes and three outputs to achieve its goals. The first outcome focuses on raising awareness within the communities across nine districts in Savannakhet province. This will involve the development of a Drought Risk Map, establishment of a National Drought Information Center, implementation of educational programs and workshops, and the provision of online platforms.

The second outcome emphasizes the exploration of alternative water sources, with a focus on groundwater. Outputs include implementing resilience solutions, sound construction, infrastructure expansion, operationalization of monitoring programs, and establishing community-based committees to enhance drought resilience.

The third outcome aims to enhance the effective utilization and sustainable management of alternative water sources. Outputs include the development of groundwater flow fluctuation charts and flow direction maps, the establishment of water usage plans, capacity-building initiatives, formation of local-based committees, implementation of public awareness campaigns, water quality testing, GIS-based mapping, the establishment of regulatory frameworks, rainwater harvesting as an alternative water source, expansion of groundwater recharge infrastructure, and monitoring of water usage efficiency.

Importance of Project

Despite its abundant water resources, Laos is an agrarian nation with a population of approximately 7.5 million and achieved a GDP growth of 4.4% in 2022. However, it faces challenges posed by anticipated water demand increases by 2040. According to the INFORM Risk Index of 2019, Laos's vulnerability to drought places it at the 69th position out of 191 countries, posing risks such as reduced crop yields, food insecurity, and water scarcity.

The Savannakhet province, identified as a drought-affected region, faces compounded challenges due to inadequate water supply for integrated water management. Moreover, the Laotian government must actively address this region's climate change and water scarcity challenges. Repeated droughts significantly affect daily life and agricultural access to water resources. Located in an area with expected temperature rises and diverse rainfall patterns, Savannakhet province experienced considerable agricultural losses totalling approximately 29 billion kips (approximately 1.48 million dollars) from 2015 to 2019, particularly in six high-risk areas, including Atsaphangthong and Thapangthong.

Addressing these issues requires an integrated approach to water resource management, improving drought risk data, and promoting sustainable water usage practices. UNDP collaborates with the Laotian government

to enhance Xe Bang Hieng watershed resilience. Targeting 581 villages and 467,204 residents, the project aims to address drought issues, improve agricultural practices, and promote community resilience, reflecting the urgency of similar project implementations.

The proposed project aims to address water scarcity issues during dry seasons by improving access to alternative water sources such as groundwater and rainwater. Adopting a gender-inclusive approach, the project strives to alleviate the challenges women face responsible for water collection during severe droughts. Benefitting a total of 467,204 individuals, including 51% women, the project addresses immediate challenges and contributes to long-term resilience in Savannakhet province, aligning with the government's commitments to integrated water resource management and climate change adaptation for sustainable and resilient futures.

Asian Water through Country

South East Asia

Philippines

"Metropolitan Waterworks and Sewerage System - Corporate Office
Maynilad Water Services, Inc.
Manila Water Company, Inc.
Luzon Clean Water Development Corporation

1. Introduction

The Metropolitan Waterworks and Sewerage System (MWSS) was established by Republic Act No. 6234 to oversee and manage the development, operations, and upkeep of the waterworks and sewerage system. Its primary duty is to guarantee a consistent and sufficient distribution of potable water for domestic and other uses at reasonable and equitable rates, and to ensure the proper operations and maintenance of sewerage systems throughout Metro Manila, the Province of Bulacan, and parts of Cavite and Rizal.

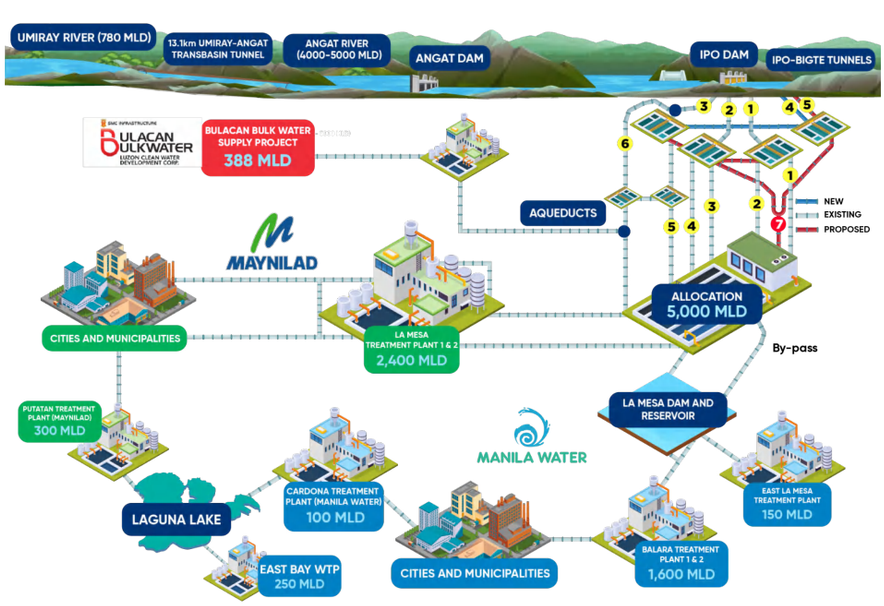
The decade of 1990's was a challenging time for the water sector of Metro Manila. The water supply coverage in the service area only ranged from 58-67%. Households only received an average of 16 hours per day of water availability—often with low water pressure—prompting them to store water in plastic drums and pails. Non-revenue water, caused by meter tampering, illegal connections, pipeline leaks, and unauthorized use of fire hydrants, was also rampant.

The Philippine Government and MWSS needed a solution. An innovative, intentional, and impactful one.

To revitalize the water sector, the Philippine Government privatized MWSS in 1997 through Republic Act No. 8041, also known as the Water Crisis Act. Maynilad Water Services, Inc. (MWSI) and the Manila Water Company, Inc. (MWCI) were granted concession agreements by the MWSS to operate and maintain the water and sewerage system in their respective service areas. As a result, citizens of Metro Manila enjoy 91% water service coverage, with over 4,618,713 residents connected to the sewerage system, as of 31 December 2023.

In 2016, the MWSS implemented the Bulacan Bulk Water Supply Project (BBWSP) resulting in the third Concessionaire of MWSS: Luzon Clean Water Development Corporation (LCWDC). LCWDC acts as MWSS' agent in supplying treated bulk water to the Water Service Providers of the Province of Bulacan.

The MWSS, the oldest water system in Asia, and its Concessionaires play a crucial role in shaping Asia's water landscape. Through collaborative efforts, best practices and forward-thinking plans, they act as a testament that public and private partnerships can emerge victorious over crises and create a sustainable and resilient water future.



2. Selected Completed Projects

(1) Umiray-Angat Transbasin Rehabilitation Project (Metropolitan Waterworks and Sewerage System)

a. Description

The Umiray-Angat Transbasin Tunnel, located at Umiray, General Nakar, Quezon Province, is the foremost structure that conveys raw water from Umiray River to the Angat Reservoir. The tunnel delivers 9 cms or 780 MLD to the Angat Dam and Reservior, which is home to 90% of the System's raw water. Considering the tunnel's importance, the Umiray-Angat Transbasin Rehabilitation Project was commenced to make it a climate-independent infrastructure facility at par with the robust Angat, Ipo, and La Mesa Dams. The project's timeline was originally from 15 April 2014 to 8 October 2015, and its revised completion was on 14 July 2023.

b. Challenges

The Umiray-Angat Transbasin Tunnel, situated in an area that was identified as prone to radical hostilities, underwent security facility breaches. This unfavorable condition was exacerbated by logistical challenges brought about by the project's remote location. Due to the above factors, the rehabilitation experienced delays.

c. Solutions

The MWSS sought the support of the Philippine Army in safeguarding the Umiray-Angat Transbasin Facility, as its rehabilitation was set to commence. Permanent Rehabilitation works for diversion structures (additional Slope protection, revetment walls and reinforcement of weir structures) and upgrading, retrofitting of intake and diversionary structures were to uncompromisingly carry on as further deferment would impact the water supply in Angat Reservoir.

(2) Angat Water Transmission Improvement Project (AWTIP) Tunnel No. 4 (Metropolitan Waterworks and Sewerage System)

a. Description

The Angat Water Transmission Project (AWTIP) Tunnel No. 4 is a Php 3.29 Billion hydraulic tunnel designed to improve the reliability of the raw water conveyance system connecting from the Angat-Ipo Dam to Bigte settling basin. The tunnel is 6.3-kilometer long with a finished, internal span diameter of 4 meters, designed to accommodate 19 cubic meters per second (m^3/s) or equivalent to 1,600 million liters of raw water per day.

Completed permanent works include (a) intake structure at Ipo reservoir, (b) new transition basin at Bigte, (c) slope protection works at Ipo Dam, (d) channel connecting Tunnel 4 outlet portal to existing Aqueduct 5 (e) Interconnection of the new transition basin at Bigte to the existing Transition Basin No. 3, and (f) the necessary modifications of the existing transition basin No. 3 at Bigte.

b. Challenges

The project faced the rehabilitation of the transmission system's main components, which is as old as 75 years and most likely not in compliance with current structural and seismic requirements. Work continued amidst the COVID-19 pandemic. The associated travel restrictions of the global phenomenon complicated the logistical

aspects of completing the project but did not pose a threat to its timely completion. The Project started in June 2016 and was completed in July 2020, three months ahead of schedule.

c. Solutions

The Asian Development Bank invested in AWTIP Tunnel No.4 to procure modern technology ensuring structural integrity and long-term raw water flow. The use of modern mechanized double blade tunnel boring technology for the tunnel excavation allowed for the full design capacity to be restored. This approach enabled sequential closure, inspection, and rehabilitation or decommissioning of the upstream tunnels and downstream aqueducts.

(3) Novaliches-Balara Aqueduct 4 (NBAQ4) Project (Manila Water Company, Inc. (MWCI))

a. Description

In January 2023, Manila Water Company, Inc. completed a Php5.3-billion (USD94,727,483) service reliability project that entails the construction of a major raw water conveyance system linking the La Mesa Reservoir located in the most populous city in Metropolitan Manila to the company's main water treatment plants. The Novaliches-Balara Aqueduct 4 (NBAQ4) project consists of laying a 7.3-kilometer, 3.1-diameter aqueduct, via a tunnel boring methodology, as well as an outlet structure at the Balara Treatment Plant 2, and the downstream network system.

Figure 2.1 Tunnel Boring Machine

The completion of the NBAQ4 project enabled the MWCI to inspect, assess, and subsequently rehabilitate the existing almost century-old concrete aqueducts, which was previously hindered by the requirement of the MWCI to provide 24/7 water service at sufficient pressure.

The Manila Water Company, Inc. is a company with extensive experience in the Philippine Water Sector from water treatment and distribution to wastewater management and sanitation services. The Company is the Concessionaire of the MWSS in the East Zone concession in Metro Manila and the province of Rizal, serving over 7.3 million population.

b. Challenges

Laying the huge pipeline along a highway with one of the heaviest traffic flows in the country was a tough feat to overcome. The trench needed to be dug for a pipeline of NBAQ4's size could potentially bring traffic flow at

a perpetual standstill for the duration of the project. An additional challenge was the impact to manpower of the community quarantine and lockdown that was imposed at the height of the construction. The decision to use a machine to create the tunnel was a result of a feasibility study conducted by the project management consultant, which was approved by government regulator, MWSS, as they were also considering the deployment of such machine in the construction of another aqueduct further upstream from Angat Dam to Ipo Dam.

c. Solutions

The construction consortium formed by local and international contractors brought in the tunnel boring machine (TBM) to be used for the project in September 2018. Designed and manufactured by Herrenknecht AG, the machine weighs 266 tons, has a cutting diameter of 3.8 meters, and is 113 meters long. Construction of its entry shaft at Balara began shortly thereafter, and by January 28, 2020, the TBM, christened "Dalisay," a Filipino word meaning pure and refined, was officially launched. Notwithstanding the challenge presented by the outbreak of the COVID-19 pandemic after its launch, especially on the project's workforce, "Dalisay" finally completed its work on August 14, 2021 when the tunnel head broke through at its exit shaft at the La Mesa Reservoir. Part of Dalisay's unique journey was digging as deep as 71 meters beneath Commonwealth Avenue and making an 84-degree turn moving towards La Mesa, a first in the Philippines where a TBM was used in an urban setting.

(4) Parañaque NEW WATER Treatment Plant (Maynilad Water Services, Inc. (Maynilad)

a. Description

Maynilad—the water and wastewater services provider of the 17 cities and municipalities that comprise the West Zone of the Greater Manila area—currently serves more than 10 million customers, around 90% of whom are served with water drawn from Angat Dam.

This dependence on a single major supply source has become problematic in recent years. As a water augmentation solution, Maynilad constructed its "NEW WATER Treatment Plant", which receives treated effluent from the company's Sewage Treatment Plant in Parañaque City and converts it into drinkable water supply. This is the first "potable water reuse" application in the Philippines, and the first in Asia to use the "direct potable reuse" scheme. The facility's treatment processes include Pressurized Media Filtration, Ultrafiltration, Reverse Osmosis, and Chlorine Disinfection. Once the treated effluent of the STP passes this second and more stringent

Figure 2.2 Parañaque NEW WATER Treatment Plant

purification process, the output is NEW WATER that now meets the 2017 Philippine National Standards for Drinking Water (PNSDW).

b. Challenges

The conversion of used water to potable water is a pioneering move in the country. So when Maynilad first introduced NEW WATER, the Philippines still had no existing regulation on "potable water reuse". All it had were regulations for the agricultural application of reused water. To address this, Maynilad worked with the relevant government agencies—including the Department of Health, Department of Environment and Natural Resources, and Metropolitan Waterworks and Sewerage System—to develop the guidelines, which will henceforth be adopted should other industry players choose to embark on a similar initiative.

c. Solutions

Maynilad sought to address social acceptability through market research, public consultations, and a major information campaign about NEW WATER. The strategy was to show the consuming public that treated effluent from STPs is a reliable raw water source, and that Maynilad can effectively convert it to PNSDW-compliant water supply.

Maynilad also extended the product water's characterization to further demonstrate its safety by analyzing organic constituents such as Geosmin, 2MIB, total Microcytins (algae toxins), and parasites Giardia, Cryptosporidium, Helminths—the first analyses of their kind to be done for water in the Philippines. These additional testing parameters will ensure that NEW WATER is safe for drinking.

(5) Bulacan Bulk Water Supply Project (BBWSP) (Luzon Clean Water Development Corporation (LCWDC))

a. Description

Luzon Clean Water Development Corp. (LCWDC) is the third concessionaire of the Metropolitan Waterworks and Sewerage System (MWSS) tasked to provide treated bulk water covering the whole Province of Bulacan, with a concession period of 30 years or until 2048. The Bulacan Bulk Water Supply Project (BBWSP) was awarded to the consortium of San Miguel Holdings Corp. and Korea Water Resources Corp. through a Public-Private Partnership (PPP) structure of Build-Operate-and-Transfer (BOT) scheme.

b. Challenges

In the previous years, prior implementation and operations of BBWSP Stages 1 & 2, the Water Districts in Bulacan Province encountered several challenges that impinged their ability to supply potable water to the service areas. In the past, the Water Districts heavily relied on groundwater as their water source. Unfortunately, with the increasing demand and continuous groundwater extraction, aquifers continuously depleted and experienced saltwater intrusion leading to poor water supply and quality. In effect, inadequate pressure was experienced by the system and the existing distribution lines were aging resulting in high Non-Revenue Water (NRW) or water losses along the network.

c. Solutions

The Bulacan Bulk Water Supply Project aims to address the water supply requirements in the Bulacan Province, thereby reducing groundwater extraction and the use of deep wells. The Project intends to supply treated bulk

Figure 2.3 388 MLD BBWSP Conventional Water Treatment Facility and Pipe Alignment

water to different water districts in the Bulacan province through the construction, operation, and maintenance of abstraction, treatment, and conveyance facilities of treated bulk water supply.

In 2016, the concessionaire started the construction of 388 MLD Water Conventional Water Treatment Plant and 66-kilometer Pipeline Conveyance Facility for Stages 1 & 2, covering 12 Water Districts. The construction was completed by 2018 followed by commercial operations in 2019. Raw water is sourced from the Angat-Ipo Dam System to address the growing demand for environmentally sustainable and equitably priced potable water within the province of Bulacan, which had relied on limited groundwater sources prior to BBWSP's operations.

The completion and operation of the Bulacan Bulk Water Supply Project has greatly contributed to providing 24/7 availability of potable bulk water supply, increase in service coverage area, ensuring optimal and reliable pressure as delivered to the interconnection points, environmentally sustainable operations and equitably priced potable bulk water supply for the people.

3. Detail of the Angat Water Transmission Improvement Project: Tunnel No. 4

(1) Description

The commissioning of the AWTIP Tunnel No. 4 began in July 2020, after the successful completion of all the components of the Angat Water Transmission Improvement Project (AWTIP) by the Metropolitan Waterworks and Sewerage System (MWSS). The accomplishment of AWTIP Tunnel No. 4 marks another milestone in the MWSS' pledge of water security for Metro Manila as it was also completed three months ahead of the scheduled time.

The centerpiece of Tunnel No. 4 is a 6.3-kilometer tunnel with a finished, internal span diameter of 4 meters, designed to accommodate 19 cubic meters per second (m^3/s or equivalent to 1,600 million liters per day) of raw water from Angat Dam. The tunnel excavation used a modern

mechanized double blade tunnel boring technology, at below ground surface depth of 200 meters and is lined with precast concrete with steel reinforcement to ensure structural integrity, and long-term raw water flow.

This Php 3.29 Billion hydraulic Tunnel No. 4 is an offshoot of the Angat Water Transmission Improvement Project (AWTIP), which involved the construction of a 5th tunnel and 7th aqueduct. These improvements modernized and interconnected the system that brings water to Metro Manila through the Ipo Dam to Bigte settling basin.

The rehabilitation of the transmission system has provided redundancy and enabled the system's full design capacity to be restored by allowing the upstream tunnels and downstream aqueducts to be sequentially closed, inspected, and rehabilitated or decommissioned.

Minor delays due to the COVID restrictions may have thwarted the best efforts to place the additional raw water into the delivery system, yet the commissioning activity pushed through ahead of its scheduled time. Its completion is a critical component for the MWSS' water security program as it mitigates the risk of a partial or total disruption of water supply for Metro Manila.

The culmination of this project is a result of the joint efforts of the Philippine Government, with MWSS as the executing agency, and the Asian Development Bank.

(2) Challenges

The project paved the way for the rehabilitation of the transmission system's main components that are as old as 75 years, which are in poor condition, and most likely not in compliance with current structural and seismic requirements. In addition, the project had to continue despite the outbreak of COVID-19 and resolve travel restrictions that came with the logistical aspect of completing the project.

(3) Solutions

The modern mechanized double blade tunnel boring technology was afforded because of the partnership of MWSS and the Asian Development Bank, a demonstration of private and public partnership. This modern technology ensured the structural integrity and long-term raw water flow is in place, at below ground surface depth of 200 meters and is lined with precast concrete with steel reinforcement. With the construction of Tunnel No. 4, AWTIP's 75-year-old main components' rehabilitation and capacity restoration was enabled.

Despite minor delays during the height of COVID-19, the commissioning activities were not halted. A 1-month testing period ensured the performance of each system and the overall system met the design standards and operating requirements that also led to the completion of the project three (3) months ahead of the scheduled time.

4. FUTURE PLANS

(1) Future Action: MWSS' Water Security Pillars

The MWSS continues to display its resilience, commitment, and adaptability in braving the several challenges of water security by (1) re-engineering its raw water conveyance infrastructure, (2) implementing short-to-medium-term water augmentation projects, and (3) building up the foundations of its long-term water source projects. With its partnership with Concessionaires Manila Water Company, Inc., Maynilad Water Services, Inc., and Luzon Clean Water Development Corporation, this three-pronged approach to security, dubbed as the Water Security Pillars of MWSS, acts as the keystone strategy of MWSS in ensuring water availability until the year 2050.

Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

South East Asia

Thailand

Office of the National Water Resources
(ONWR)

1. Introduction

(1) Thailand's Water Resources Management

Thailand is located in the tropical zone near the equator, which exposes most of the country's land area to monsoon winds, making it a land rich in water resources. The country can be divided into 22 main river basins. However, despite an annual water flow of approximately 200 billion cubic meters, the country faces challenges due to its limited storage capacity, which is only about 78 billion cubic meters, while demand is reaching approximately 150 billion cubic meters. This constraint poses difficulties in meeting the escalating demand driven by factors such as economic growth, population expansion, and the effects of climate change.

To address these challenges, Thailand has adopted a comprehensive approach to water resources management, known as the "3 pillars of water resources management.". The Water Resources Act, a cornerstone of legislation, serves as the first pillar of this framework, promoting the integrated management of Thailand's water resources. Through this act, the country endeavors to streamline its water-related policies, optimize budget allocations, and foster greater coordination among various stakeholders. By reducing redundancies and enhancing coherence in action plans, the Water Resources Act seeks to lay a solid foundation for effective water governance.

The second pillar focuses on organizational structures; central to this pillar are institutions such as the National Water Resources Committee, the Office of the National Water Resources, and 22 River Basin Committees. These entities are tasked with the formulation of policies, the development of work plans, and project budgets at both national and river basin levels, as well as integrating coordination among various water-related agencies.

The third pillar is the 20-year water resources master plan (2018-2037), which outlines strategic initiatives aimed at addressing key challenges such as water consumption, water security in production sectors, flood management, conservation and restoration of water ecosystems, and management. By providing a roadmap for sustainable water management, the master plan serves as a guiding framework for decision-makers, ensuring that water services remain accessible, supporting economic growth, and safeguarding precious ecosystems.

These three main pillars represented a concerted effort by Thailand to navigate the complexities of water resource management towards greater efficiency. It is also critical to building a unified and effective strategy to manage water resources for the country's sustainable development.

(2) The Office of the National Water Resources (ONWR)

Among the three pillars of Thailand's water resources management, the Office of the National Water Resources (ONWR stands as a cornerstone institution tasked with integrating and sustaining effective water management practices. Through its mandate and missions, ONWR's missions cover four major areas, including the formulation of water policies at the national and river basin levels, screening plans and projects for consistency with the National Strategy, supervising, monitoring, and evaluating water resources management nationwide, and promoting integration and participation based on good governance principles.

At the national level, ONWR's extensive network of over 50 water-related agencies is securely and actively linked to supervise and direct national water management. Through this collaborative approach, ONWR ensures that water resources are managed efficiently and effectively to meet the diverse needs of the country, balancing economic development with environmental conservation.

Moving to the regional level, ONWR serves as the Secretariat and the Focal Point for the Joint Working Group on Water Resources Cooperation, guiding and representing Thai interests in transboundary water management, underscoring Thailand's commitment to regional cooperation and sustainable water use.

Moreover, at a global scale, ONWR has entered into active Memorandums of Understanding (MOUs) on water resources management with various international partners. These agreements facilitate coordination with designated implementing agencies, enabling Thailand to exchange knowledge, expertise, and best practices with international partners. This global engagement reflects Thailand's dedication to international cooperation and sustainable water management practices that transcend national boundaries.

2. Selected Completed Projects

(1) National ThaiWater (NTW)

a. Description

The National ThaiWater is a tool designed to facilitate water situation monitoring and management across various levels, ranging from provincial, river basin, and national levels for water-related agencies and individuals, providing access to crucial data pertaining to rainfall, water runoff, and water availability in water sources. This platform collects analyzed information including weather forecast, early-warning, water situation information for efficient and timely water situation management. It also collects technical information for water-related experts and agencies, including hydro-meteorological data which are data from each water station, case, rainfall station, water level station, rain statistics, storm path, rain forecast, information on large and medium scale water sources, information from the flood and landslide early warning system (EWS), wave forecast information, water quality information, disaster area information.

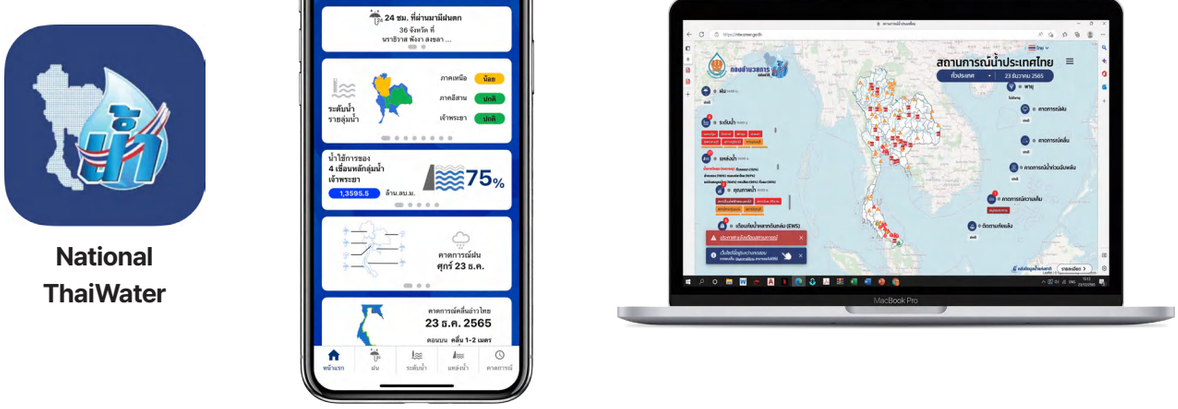


Figure 2.1 National ThaiWater Application and Website

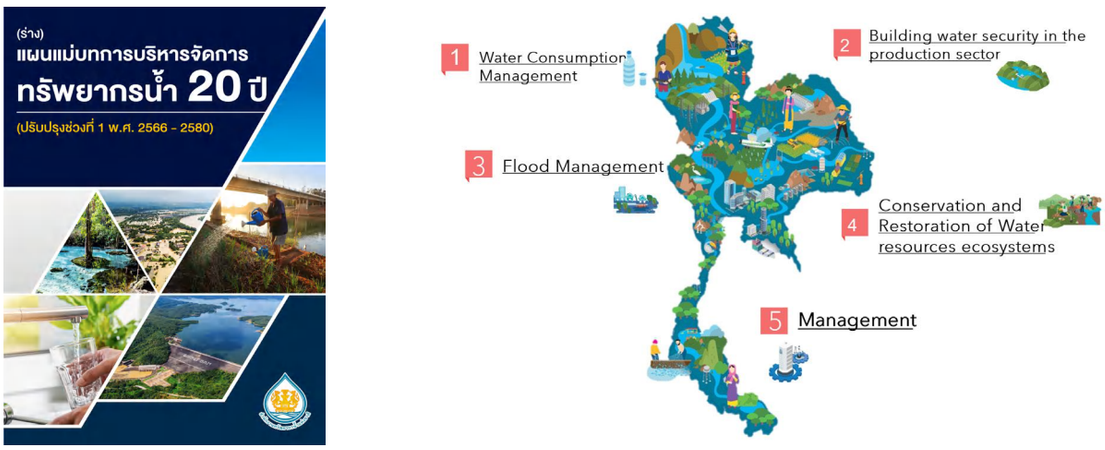


Figure 2.2 20-Year Master Plan on Water Resources Management (First Revision, 2023 - 2037)

b. Challenges

Gathering near real-time data and information from various related agencies, analyzing it, and displaying the analyzed data and information in a sustainable manner can be challenging. The main issue is that each agency has its own approach to data collecting. In order to provide more targeted alerts, higher-quality data, including more frequent and extensive data collecting, are required.

c. Solutions

- To address these challenges, the following strategies could be instrumental:
- Establish data standards for data exchange among all agencies.
- Promote the installation of water stations where necessary for analysis and warnings.
- Enhance the display interface to make it more user-friendly and easier for stakeholders to navigate.

(2) Revision of the 20-Year Master Plan on Water Resources Management

a. Description

The 20-Year Master Plan on Water Resources Management, the third pillar of water resources management in Thailand, outlines strategic directives for water resources management over a 20-year period. Revised every 5 years to adapt to the dynamic environmental situation, the updated version covers five main areas: management of water for consumption, water security in production sectors, management of flood and water-related disaster, conservation and restoration of water ecosystems, and comprehensive water resources governance.

b. Challenges

Water resources management may face several challenges in the future, including the impacts of the COVID-19 pandemic and climate change. The pandemic, in particular, has triggered rural return migration, with people returning to agricultural work. This has increased the demand for water for agriculture, highlighting the need to develop small water storages systems distributed to communities for farmers. To address these challenges, the adoption of digital technology can improve water resource management by reducing costs, time, workforce, and budget for management and maintenance. This leads to the revision of the master plan on water resources management to incorporate these new technologies and effectively address emerging challenges.

c. Solutions

To enhance the implementation of the 20-Year Master Plan on Water Resources Management and offer effective solutions to the emerging water challenges, the Master Plan was first revised through a comprehensive review of monitoring and assessment data, project outputs, outcomes, and achievements. This review aimed to improve and align the Master Plan's goals, address gaps, obstacles, problems, and limitations hindering goal achievement, and ensure that the plan remains relevant and effective. The revision process also involved updating and refining subplans by forecasting potential future situations, creating initiatives, conducting experiments, and researching to further expand the plan's outcomes. The revision also addressed cross-cutting issues and external impacts. In addition, public hearings were organized to gather the opinions and voices of stakeholders, including the government, the public, private agencies, and other relevant stakeholders. This inclusive approach ensured that the revised Master Plan reflected the needs and aspirations of all stakeholders involved in water resources management.

(3) Action Plan on Clean Water for Consumption

a. Description

Recognizing the critical importance of ensuring water consumption security and improving access to clean water across all sectors, aligning with the sustainable development goals. To achieve this, Thailand has developed an Action Plan on Clean Water for Consumption (2023 – 2037), which consists of four strategies and thirteen work plans.

The first strategy focuses on the development and expansion of the water supply system area to ensure broader coverage and accessibility to clean water. The second strategy aims to increase plumbing efficiency and enhance water availability, especially in areas facing water scarcity. The third strategy emphasizes the monitoring and inspection of water quality for consumption, ensuring that it meets the required standards to safeguard public health. The final strategy focuses on effective water management practices to ensure sustainable use and conservation of water resources.

Figure 2.3 Action Plan on Clean Water for Consumption (2023 – 2037)

b. Challenges

The demand for water for consumption is on the rise due to economic expansion, population growth, and urbanization. Climate change and more severe water-related disasters further intensify this trend by affecting the quality of tap water and its services. However, several challenges hinder efforts to enhance access to water for all.

One major challenge is the lack of budget for a comprehensive implementation of waterworks system service management. Additionally, there is a need for better integration of knowledge and a unified database to effectively manage water services. These challenges must be addressed to ensure sustainable access to clean water for all sectors of society.

c. Solutions

To facilitate the implementation of clean water for consumption and align with the goal of comprehensive water and sanitation management, Thailand has established the Action Plan on Clean Water for Consumption (2023

– 2037). This Action Plan consists of four strategies and thirteen work plans aimed at improving waterworks system maintenance, developing and expanding tap water systems, increasing water availability, ensuring water for consumption meets standards, and enhancing overall management.

Each strategy within the action plan has specific targets, key performance indicators (KPIs), responsible and implementing agencies, and estimated budgets for implementation, monitoring, and evaluation. The goal is to ensure that every village in the country, as well as urban areas, have access to sufficient clean water for consumption.

3. Detail of the 20-Year Master Plan on Water Resources Management (First Revision, 2023 - 2037)

(1) Description

Rationale

The National Water Resources Committee has assigned the Office of the National Water Resources to collaborate with relevant agencies and sectors to develop a 20-Year Master Plan on Water Resources Management. This Master Plan serves as a framework and guideline for addressing water resource issues, improving basin-based water management, optimizing the overall productivity of the water system, and developing a system for managing water disasters. The ultimate goal is to achieve the vision of "Thailand having sustainable water resources management with the participation of all sectors, under balanced and dynamic development for water security in all dimensions." To achieve this vision, the 20-Year Master Plan on Water Resources Management has been revised and specified in five key strategies.

Five strategies of the 20-Year Master Plan on Water Resources Management (First Revision, 2023 - 2037)

The first strategy: Water Consumption Management

- The goals of this strategy include:
- Providing clean water for consumption to all communities, villages, urban communities, important tourist attractions, and special economic areas.
- Improving the long-lasting village water supply system.
- Reducing duplication in water supply service areas.
- Providing alternative water sources in areas facing water scarcity.
- Ensuring that drinking water meets standards at a reasonable price.
- Reducing non-revenue water in the distribution system.
- Promoting water conservation by reducing water use in households, services, and government sectors.

The second strategy: Creating water security in the manufacturing sector

The goals of this strategy include:

- Developing new water storage and water delivery systems to their full potential.
- Increasing the efficiency of water resource projects and the original water delivery system in irrigated areas

through land readjustment.

- Promoting the cultivation of xerophyte crops to reduce water consumption.
- Adjusting the water use structure.
- Increasing water use productivity.
- Creating stability for production by ensuring a balance between water availability and water use.

The third strategy: Flood and water-related disasters management

The goals of this strategy include:

- Increasing drainage efficiency.
- Organizing flood prevention systems for urban communities.
- Managing flood areas and water slowdown areas.
- Implementing area-based flood mitigation measures systematically at the basin level and critical areas.
- Solving problems with nature-based solutions.
- Increasing the capacity of local government organizations to adapt to and cope with disasters.
- Improving dams and reservoirs to enhance resilience to climate change.
- Preparing plans for emergency situations.

The fourth strategy: Conservation and restoration of water resource ecosystems

The goals of this strategy include:

- Conserving and restoring degraded watershed forest areas.
- Preventing and reducing soil erosion in watersheds and agricultural areas outside conservation areas.
- Developing and increasing the efficiency of wastewater collection and treatment systems in urban areas.
- Promoting the collection of community wastewater treatment fees.
- Reusing wastewater.
- Preventing and reducing wastewater generation at the source.
- Restoring rivers, canals, wetland areas, and natural water sources for conservation and utilization throughout the country.
- Reducing saltwater intrusion and erosion in river mouths.

The fifth strategy: Management

The goals of this strategy include:

- Driving water resource management through legislative amendment.
- Developing decision-support databases that promote and support cooperation both within and outside the country.
- Managing water resources using technology.
- Campaigning to encourage people to use water economically.
- Developing research, innovation, and technology to support the creation of added value in the manufacturing and service sectors, raising the level of work to meet international standards.

(2) Challenges on future water resources management

The outbreak of the COVID-19 pandemic has led to rural return migration, which has consequently increased the demand for water for agriculture. As a result, water management needs to focus on developing water availability,

particularly small water sources, to distribute among communities for farmers to sustain their livelihoods.
Climate change impacts water resources and hydrological management, affecting both the quantity and quality of water. Therefore, planning must include an analysis of the current situation and risk areas to determine guidelines, measures, and plans for water resource management that can effectively address these impacts.

(3) Solutions

Utilizing Nature-based solutions which is a holistic management approach that relies on knowledge and understanding of nature, ecosystems, and biodiversity. This approach involves gradually developing the maintenance of the area to be consistent with reality. The revision of the Master Plan has applied this concept to solve water resource problems, aiming to achieve a balance between development and conservation.
Ecosystem-based adaptation, which involves using biodiversity and ecosystem benefits as part of an overall approach to help humans cope with the negative impacts of climate change.
Utilizing digital technology in water management increases efficiency by streamlining the analysis process and providing up-to-date information. This approach reduces costs, time, labor, and budget required for management and maintenance.
According to the World Bank, a conceptual framework called "Water in Circular Economy and Resilience (WICER)," which connects water, energy, and food sectors, facilitates the reuse of wastewater from industrial, agricultural, and urban contexts. The revised Master Plan has adopted this concept as a guideline for further development, prioritizing water reuse and improving water use efficiency in the agricultural and industrial sectors.

4. Future Plan

Implementation of the Action Plan on Clean Water for Consumption
Under the 20-Year Master Plan on Water Resources Management (First Revision, 2023 - 2037), the first strategy, Water Consumption Management, is crucial for the well-being of people and aligns with Sustainable Development Goal 6 (SDG 6). Projects related to this strategy will be implemented at the basin level, with the Action Plan on Clean Water for Consumption driving these initiatives. Budget allocations have been made at both central and local agency levels for the repair and maintenance of water supply systems, the development and expansion of plumbing systems, and the enhancement of water availability. The goal is to achieve the national targets of SDG 6, ensuring access to safe and affordable drinking water for all by 2030, as well as access to adequate sanitation and hygiene, with particular attention to the needs of women, girls, and vulnerable groups.

5. References

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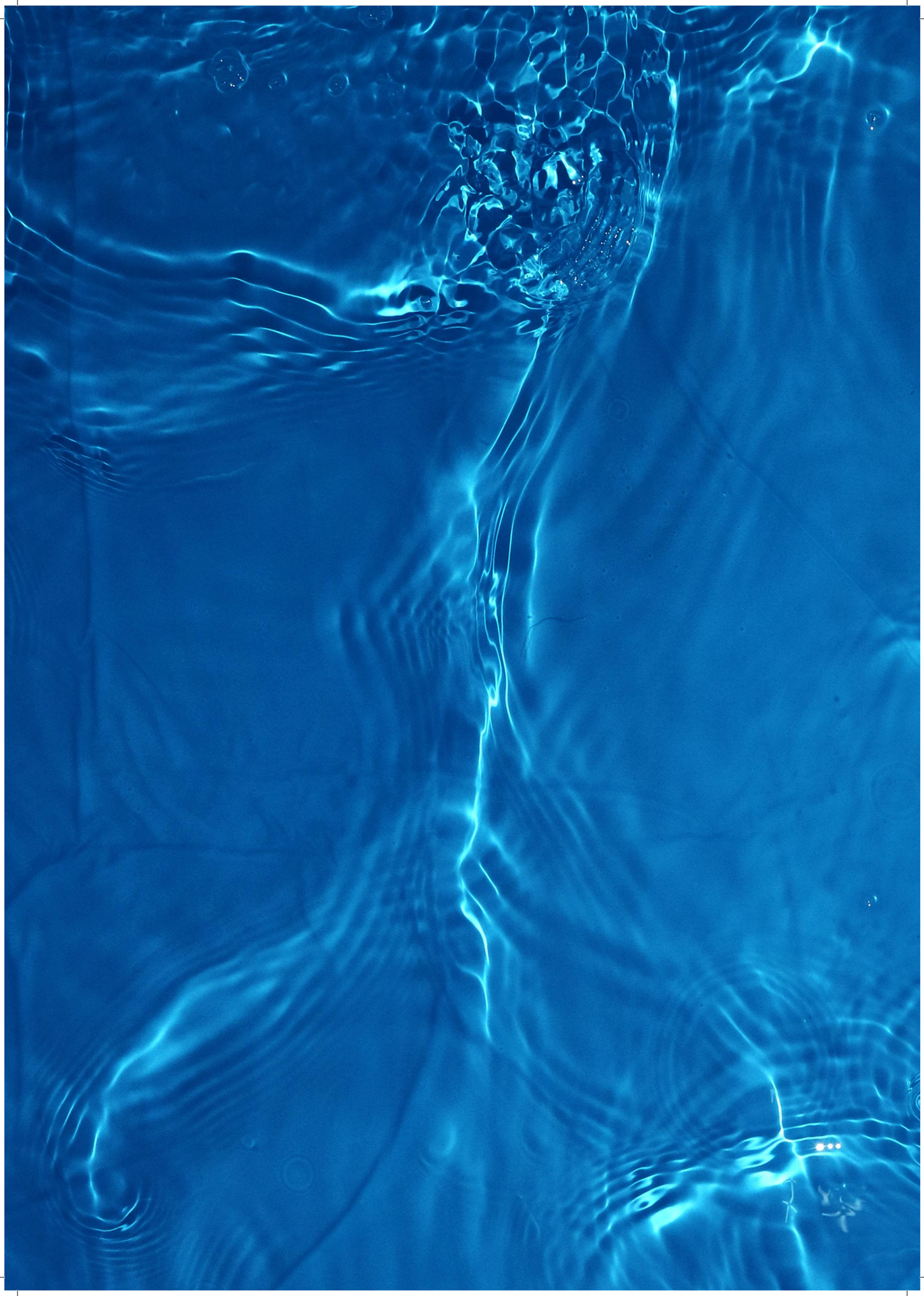


Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

South East Asia

Vietnam

National Center for
Water Resources Planning and Investigation
(NAWAPI)

1. Introduction

(1) Water Resources of Vietnam

Water resources in Vietnam face significant challenges and complexities due to various factors such as climate change, transboundary water resources, and the food-energy-water nexus. The current status of water resources in Vietnam's numerous river basins reflects a mix of water abundance and scarcity, uneven distribution across different regions and river systems. Ensuring the availability of water resources and their sustainable management are crucial for water security in Vietnam.

Key aspects such as water availability, current status of water exploitation and use, wastewater and water pollution, water resource management organization, and water-related disasters are essential considerations in assessing Vietnam's water security. These factors are interconnected and impact the overall water security in the region.

Addressing challenges related to climate change and sea-level rise is critical, as these factors significantly affect water resources through changes in rainfall patterns, river flow, and water quality. Socioeconomic development, including food and energy demands, can strain water resources and lead to pollution, exacerbating water security issues. Transboundary water resources also play a vital role, as Vietnam heavily depends on rivers that flow through neighboring countries such as Mekong River and Da River.

To enhance water security in Vietnam, solutions need to be implemented at both structural and nonstructural levels. Strengthening integrated water resource management practices, enhancing cooperation for international river basin management, improving water pollution control measures, and developing adaptive strategies to manage extreme weather events are essential steps.

Addressing water security challenges in Vietnam requires a comprehensive approach that considers various factors impacting water resources. By focusing on sustainable management practices, addressing pollution, adapting to climate change, and fostering international cooperation, Vietnam can work towards ensuring water security for its population and sustainable development.

(2) National Center for Water Resources Planning and Investigation (NAWAPI)

NAWAPI is a crucial institution in Vietnam responsible for water management, planning, and conservation. Established to address complex water system challenges, NAWAPI aims to ensure sustainable water resource utilization and environmental protection across Vietnam. The center's objectives include developing comprehensive water plans, conducting water resource investigations, and implementing water-related projects. NAWAPI's functions encompass hydrological assessments, groundwater studies, water quality monitoring, irrigation planning, and flood risk assessments. The center is involved in projects like Integrated Water Resource Management (IWRM), water infrastructure development, water quality improvement initiatives, and climate change adaptation strategies.

NAWAPI's work is vital for promoting water security, supporting sustainable development, and enhancing resilience to climate change impacts. By developing comprehensive water planning and conducting investigations, NAWAPI contributes to ensuring reliable water supply and quality in Vietnam. The center integrates water management practices across different sectors such as agriculture, industry, and urban

planning to promote economic growth while preserving the environment. NAWAPI collaborates with government agencies, research institutions, and international organizations to share expertise and promote best practices in water resources planning and management.

NAWAPI's significance lies in its pivotal role in shaping water resources planning, management, and infrastructure development in Vietnam. The center's multifaceted functions and engagement in related projects demonstrate its commitment to driving positive change in the water sector. Ultimately, NAWAPI's contributions to water security, sustainable development, and environmental preservation make it a key institution in Vietnam's water management landscape.

2. Selected Completed Projects

(1) Pre-Fisibility Study of SWM construction Project in Ha-Tinh

a. Challenges

The operational challenges faced by Vietnam's water supply system mirror common struggles in many developing nations. Addressing the issue of high Non-Revenue Water (NRW) is pivotal not just for efficiency but also for sustainable water management. The gravity of NRW problems extends beyond economic losses, encompassing water quality issues, health risks, and threats to resource sustainability. Water restrictions, viewed as temporary measures, can have lasting repercussions like pipe network deterioration and diminished quality. Embracing technological advancements, such as IoT-based smart solutions, is essential for effective water management, enabling real-time data collection, leak detection, and quality monitoring. To holistically tackle water management challenges, Vietnam requires a comprehensive strategy integrating public-private cooperation, regulatory frameworks, technological innovations, and community involvement, setting the stage for a transformative shift toward a more sustainable and efficient water supply system.

b. Solutions

In Ha Tin City, a comprehensive Smart Water Management plan is in progress to revolutionize water resource management practices. The strategy includes measures to decrease Non-Revenue Water (NRW), establish District Metered Areas (DMAs) equipped with advanced tools, integrate IoT-driven leak detection sensors for accurate monitoring, and develop a maintenance infrastructure for real-time data analysis. This initiative sets out to elevate water management efficiency, diminish water loss, and foster sustainable utilization of water resources throughout the city. Ha Tin City is striving to manage NRW below 15% by 2025 by forming a dedicated Leakage Detection Team and utilizing smart leak detection sensors for proactive leak identification. Following the International Water Association (IWA) guidelines, the city plans to design and equip DMAs with essential components like flow meters, boundary valves, pressure gauges, and other critical instruments, ensuring standardized and effective water distribution networks. To combat water loss, Ha Tin City is set to deploy cutting-edge IoT leak detection sensors such as vibration sensors and hydrophones strategically to promptly detect and locate leaks with precision. The maintenance system implementation blueprint encompasses a range of detection systems for monitoring water flow and pressure in real-time, facilitating informed decision-making processes for efficient water management. By executing these initiatives, Ha Tin City aims to elevate its smart

water management practices, curtail water loss, and establish a sustainable framework for managing water resources effectively and responsibly across the region.

(2) Establishment of DSS for Efficient Water Mgmt.

a. Challenges

Ha Noi, the capital of Vietnam, boasts an expansive area of 3,359 km² and is home to over 8.1 million residents across its 30 administrative districts, as highlighted in the Statistical Yearbook of Vietnam 2020. However, the alarming pollution levels in the surrounding rivers, primarily the Nue River, are attributed to the rapid urbanization and industrialization in the city, leading to significant economic losses and adverse effects on public health. Efforts to counteract this issue include plans to establish a water quality monitoring system in the Nue River, crucial for the region's agriculture, positioning observatories strategically for efficient pollution management, and developing a robust database for water quality modeling to be integrated into a real-time Water Quality Improvement Decision Support System (DSS).

b. Solutions

The rapid urbanization and industrial expansion in Hanoi, Vietnam have led to a pressing challenge of untreated wastewater discharge from various industrial sources into rivers, particularly the Tolic River, resulting in severe water quality degradation. The Nue River has witnessed a significant decline in water quality, with its Water Quality Index dropping below 25, necessitating urgent measures for water quality improvement. Despite efforts to enhance water quality by extracting Red River water during dry seasons, diminishing flow rates have hindered progress, causing severe pollution and water scarcity issues, especially affecting downstream agriculture and leading to potential water disputes. Implementing effective river water quality management in the project area amidst Hanoi City's rapid urban growth is facing obstacles due to inadequate sewage regulations and disjointed water treatment facility development; these highlight the urgent need to form a synchronized and efficient governance framework.

To address the imperative for upgrading water quality standards in the project zone and aligning with agricultural water quality benchmarks, a comprehensive plan is being formulated. This plan includes the implementation of a real-time water quality monitoring system, a predictive decision support system to forecast water pollution loads using a tailored water quality model. Utilizing the MIKE11 model's modules encompassing Hydrodynamics, Rainfall-runoff, Diffusion Transport, and Ecological aspects specific to the Nue River region in Vietnam, the strategy aims to establish a sustainable decision support system for future water management strategies. The Vietnamese government's commitment to enhancing the Nue River's water quality reflects a strategic vision to position Hanoi as a hub of well-maintained natural water resources, highlighting potential business opportunities post the project's completion evaluation. Integrating an extensive database for the Nue River basin and establishing real-time data transmission systems for monitoring various water quality parameters underscore the evolution of an operational management system designed to consolidate diverse data for informed decision-making in water resource management.

3. Detail of the "Pre-Feasibility Study of SWM construction Project in Ha-Tinh"

(1) Context

These problems related to the operational status of Vietnam's water supply system are common difficulties not only in Vietnam but also in many developing countries. Although high rates of Non-Revenue Water (NRW) can actually significantly reduce the efficiency and economics of water systems and cause serious problems for water supply due to limited resources, it also means there is a lot of room for improvement.

The severity of the NRW problem: NRW problems in Vietnam's water supply network not only mean economic losses, but also cause water quality problems, public health threats, and challenges for sustainable water resource management. To meet the growing demands of urbanization and population growth, it becomes important to use limited water resources as efficiently as possible.

Negative effects of water restrictions: Water restrictions may seem like a temporary solution, but in the long run, they can lead to deterioration of the pipe network system and reduced water quality. During water irrigation, external contaminants can find their way inside, and changes in water pressure can stress the plumbing system, causing more leaks and breaks.

The importance of technological approaches: Reducing NRW requires the introduction of new technologies and smart solutions. For efficient tap water management, an IoT-based smart system that can collect and analyze data in real time is important. These systems enable a variety of activities such as leak detection, water quality monitoring, and pressure management, allowing managers and operators to manage the system more accurately and efficiently.

The need for a comprehensive water resources management strategy: Vietnam needs a comprehensive strategy to increase the efficiency of water resource management, including NRW issues. This must include public and private sector collaboration, legal and policy support, technological innovation and community engagement.

In this context, this project will be an important step towards improving Vietnam's water supply system. The project is expected to introduce improved technologies, reduce water leakage rates and implement new approaches to sustainable water.

Figure 3.1 Installed valve boxes in Vietnam

(2) Detail plan of the Smart Water Management

In Ha Tin City, a Smart Water Management plan is being developed to enhance water resource management. The plan includes strategies to reduce Non-Revenue Water (NRW), establish District Metered Areas (DMAs) with advanced equipment, implement IoT-based leak detection sensors for efficient leak monitoring, and set up a maintenance system for real-time data analysis. This initiative aims to improve water management practices, minimize water loss, and ensure sustainable water resource utilization in the city.

NRW Management

Ha Tin City aims to manage Non-Revenue Water (NRW) below 15% by 2025. To achieve this, a Leakage Detection Team will be established with around 20 inspectors. The city plans to adopt innovative methods such as implementing smart leak detection sensors to predict and detect leaks in real-time.

DMA Design and Equipment Plan For effective management

Ha Tin City will follow the International Water Association (IWA) guidelines in designing and standardizing District Metered Areas (DMAs). This involves installing DMA flow meters, boundary valves, pressure gauges, pressure reducing valves, small flow meters, and other necessary equipment.

Leakage Reduction Equipment Plan

To reduce water loss, the city plans to introduce IoT-based leak detection sensors, including vibration sensors and hydrophones, to predict and locate leaks accurately. These sensors will be strategically placed to monitor and analyze leaks effectively.

Maintenance System Implementation Plan

The maintenance system will include a comprehensive water flow detection system, medium, and small-block flow monitoring systems, and a minimum flow monitoring system. These systems will enable real-time monitoring and analysis of water flow and pressure, aiding in decision-making processes.
By implementing these initiatives, Ha Tin City aims to enhance its smart water management practices, minimize water loss, and ensure sustainable and efficient water resource management in the region.

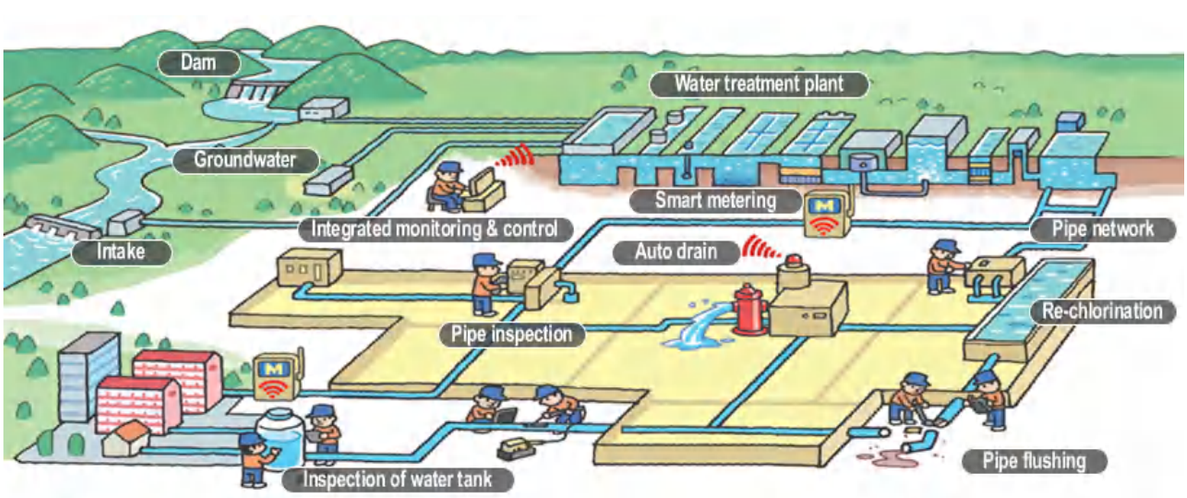


Figure 3.2 Scheme of Smart Water Management

4. Detail of the "Establishment of DSS for Efficient Water Mgmt."

(1) Context

Ha Noi, the capital of Vietnam, situated in the Red River Plain Delta with an area of 3,359 km², encompasses 30 administrative districts and hosts a vast population exceeding 8.1 million residents, as per the Statistical Yearbook of Vietnam 2020. The Center for Environment and Community Research (CECR) in Vietnam has highlighted the alarming pollution of surrounding rivers, attributable to the unbridled urbanization and industrialization of Ha Noi, causing widespread economic losses and detrimental impacts on public health. Emissions of untreated wastewater from industrial complexes, export processing zones, and hospitals have dramatically tainted the waterways, particularly the Nue River, by becoming the primary wastewater discharge point in Vietnam. Despite attempts to mitigate water quality through the influx of Red River water via the Line Mac floodgate, the worsening drought conditions have impeded progress, resulting in a decline in the Nue River's water quality, with a Water Quality Index (WQI) ranging from 10 to 25 as assessed by NVWATER's Northern Division of Water Resources Planning and Investigation. Thus, the business objectives entail formulating a water quality monitoring and warning system to alleviate pollution in the Nue River, a vital water source for agriculture in southern Ha Noi, optimizing water quality observatory locations for efficient management, and devising a pollution load database for water quality modeling, complemented by a real-time monitoring system-based Water Quality Improvement Decision Support System (DSS).

Figure 4.1 Pollution in Nue river

(2) Detail plan of the Establishment of DSS for Efficient Water Mgmt.

The accelerated urbanization and industrial growth in Hanoi, Vietnam has precipitated (meaning? Should it be replaced with "looked into"?) a critical conundrum around untreated wastewater disposal from industrial and craft complexes, leading to the direct contamination of rivers and underscoring substantial wastewater treatment concerns. A majority of effluents from residential areas, craft factories, textile, and dyeing units are unconstrainedly discharged into the Tolic River without treatment, exacerbating water quality issues as the Nue River encounters a drastic decline with a water quality index plummeting below 25, necessitating an urgent

realignment for water quality enhancement. The dry seasons have witnessed a reprehensible scenario where initiatives to elevate water quality and ensure agricultural water supply through the extraction of Red River water have faltered owing to declining flow rates, provoking severe water pollution and stench while jeopardizing downstream agricultural supplies and engendering potential water disputes due to scarcities.

Presently, within the project vicinity, effective river water quality management is confronting impediments amidst Hanoi City's exponential urban growth, with inadequate sewage discharge regulations and treatment policies precipitating a disjointed spurt in water treatment facility development bereft of a cohesive and introspective governance framework. The imperative to refurbish water quality standards in the project domain necessitates a paradigm shift in river management by harmonizing with local residents, water management entities, and allied organizations to amalgamate and promulgate essential data cogently, establishing a synchronized and efficient system.

In unequivocal pursuit of bolstering water quality standards in the engrossing project zone and fostering equilibrium with the agricultural water quality benchmarks, an encompassing regimen is being devised incorporating a real-time water quality monitoring system, a predictive decision support system architectural essence prognosticating water pollution loads via a bespoke water quality model. Ergo, this appraisal encapsulates a meticulous water pollution causation dissection upheld by an optimal simulation leveraging the MIKE11 model's distinct modules encompassing Hydrodynamics, Rainfall-runoff, Diffusion Transport, and Ecological facets quintessentially harnessed in Vietnam for the Nue River riparian turf, mandating the inception of a protracted decision support system (DSS) facilitating futuristic management stratagems.

The Vietnamese administration's robust resolve to enhance the Nue River's water quality resonates through the strategic connotations, steered toward rendering Hanoi, the nation's pivotal focal point, an enclave of pristinely preserved natural water resources, thereby underlining the decisive business aptitude ripe for actual infrastructure implementation post the systems completion evaluation. Set against the backdrop of the adroitly articulated establishment of an integrated database for the Nue River basin, the investigative odyssey concerning extant water quality monitoring nodes impels the crafting of a real-time data transmission system to encapsulate diverse water quality parameters encompassing temperature, pH, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), Ammonium Nitrogen (N-NH4+), Total Nitrogen (TN), Total Phosphorus (TP), turbidity, and diverse heavy metals (Cu, Pb, Zn, Cd), underscoring the maturation of an operation management system orchestrating harmonious data amalgamation. These orchestrated mechanisms, buttressed by an invigorated water quality modeling edifice grounded on the acclaimed MIKE11 suite, cogently dovetail into the overarching fabric christened the integrated database sculpted to sculpt and invigorate a data-driven milieu culminating in judicious waterscape decision-making.

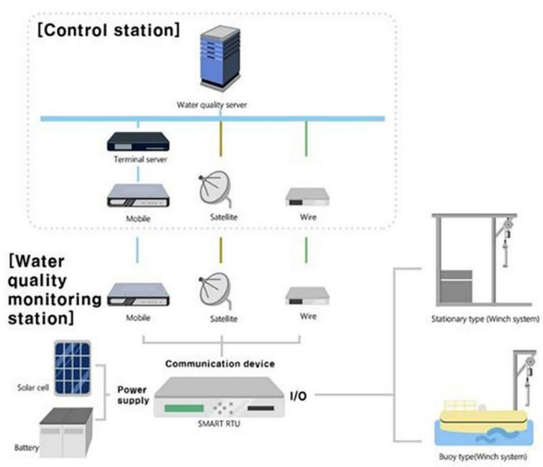


Figure 4.2 Planning of DSS for efficient water management

5. Future Plan

(1) SWM construction Project in Ha-Tinh

In the dynamic setting of Ha Tin City, the forthcoming strategy for Smart Water Management embodies a comprehensive and diverse approach. The municipality aims to revolutionize water system oversight through the adept use of cutting-edge technologies like IoT sensors, data analytics, and automation, fostering real-time insights and operational control. Furthermore, a concerted effort is underway to expand District Metered Areas (DMAs) extensively, enhancing operational efficiency, bolstering leak detection capabilities, and ameliorating the broader water distribution landscape. Recognizing the pivotal role of skill development, Ha Tin City is resolute in delivering robust capacity-building and training programs to empower its workforce with the requisite expertise for leveraging the smart water management system and making informed decisions. Collaborative efforts with technology providers, water experts, and stakeholders stand at the forefront of the agenda, ensuring a continuous exchange of knowledge and best practices to propel smart water management forward. The strategic blueprint also emphasizes the significance of ongoing monitoring, analysis, and evaluation to pinpoint areas for improvement, optimize system performance, and foster sustainable water resource utilization. In line with its commitment to community engagement, Ha Tin City is set to unveil a series of public awareness initiatives to champion water conservation, foster active participation in sustainable water management practices, and instill a culture of conscientious water consumption. Through a targeted focus on these critical initiatives, Ha Tin City endeavors to establish an enduring, efficient, and sustainable Smart Water Management system that not only curtails losses but also maximizes the prudent use of water resources for the well-being of its residents and the ecosystem.

(2) Establishment of DSS for Efficient Water Management

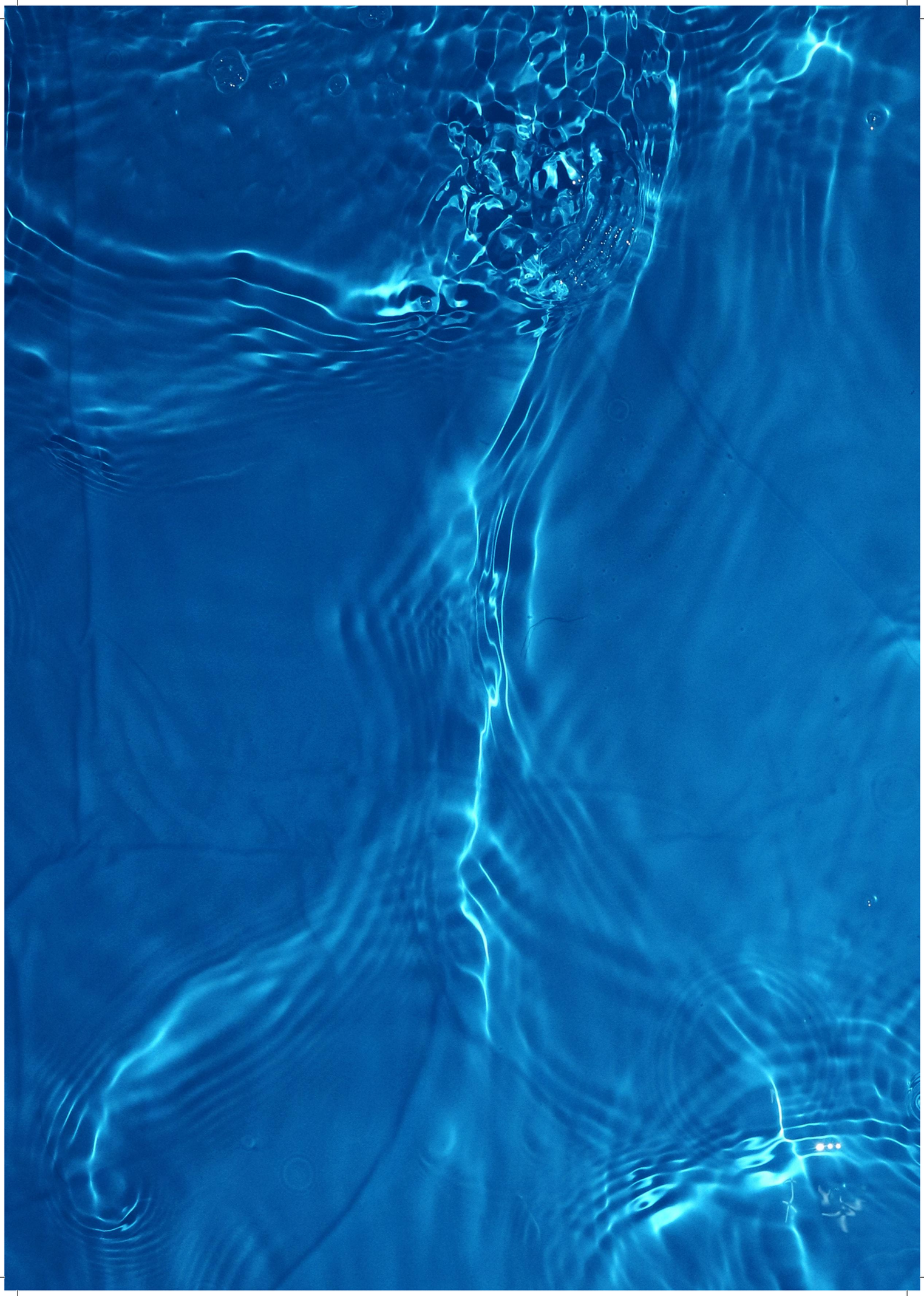
The comprehensive future strategy for water quality management in the Nue River basin encompasses several critical initiatives. Firstly, there will be the implementation of an integrated database to streamline and enhance water quality monitoring processes to ensure timely and accurate data collection and analysis. Additionally, on-site investigations at existing monitoring points will be conducted to guarantee thorough coverage and data accuracy. A real-time transmission system will be established to monitor crucial factors such as temperature, pH levels, oxygen content, pollutants, and heavy metal concentrations swiftly and efficiently. Furthermore, the development of an operation management system will facilitate the seamless integration and dissemination of data across various monitoring points and stakeholders. Leveraging the advanced MIKE11 platform, a specialized water quality modeling system will be deployed to provide informed decisions based on accurate predictive modeling and analysis. The establishment of an observation post and operational hub will be vital for continuous monitoring of water quality parameters and flow rates to ensure proactive management and rapid response to any deviations. In addition, an integrated operation organization and water resource center will be designed to streamline observatory functions and ensure cohesive management practices. Introducing a mobile-based management system will provide on-field personnel with real-time access to critical data and monitoring tools. To enhance accessibility and transparency, the creation of a digital platform such as a dedicated website will offer seamless access to data, insights, and reports for all stakeholders involved in water quality management.

Ultimately, implementing a robust decision support system will be pivotal in leveraging environmental data to conduct in-depth analysis, drive strategic decision-making, and elevate water quality standards for sustained enhancement and ecological preservation in the Nue River basin.

6. References

Pre-F/S for smart water management construction project in Ha-Tinh, Vietnam (2024)

Establishment of Decision Support System (DSS) for Efficient Water Resources Management in Vietnam (2021)



Asian Water through Country

South Asia

Bangladesh

Dhaka Water Supply and Sewerage Authority
(DWASA)

1. Introduction

Dhaka Water Supply and Sewerage Authority (DWASA) is mandated to provide water supply and sewerage facilities to the residents of megacity Dhaka. DWASA has been providing dedicated service for safe water to the city dwellers since 1963.The first water treatment plant was established in Dhaka city by Nawab Khaza Abdul Ghani in Chandni ghat named "Dhaka Water Works" in the year 1874, which is also the 1st water treatment plant in South Asia (DWASA, 2023). The piped water supply was started in Dhaka city from that time.

As these pipe lines were constructed almost 150 years ago and over the course of time became leaky causing 40- 45% of non-revenue water. Due to this leakage the water demand of city dwellers could not be fulfilled and on the other hand DWASA was not getting the revenue. At the same time because of the leakage, contamination occurred through this leakage when water pressure was low. Due to this unaccounted-for water, it became difficult to supply water to the people causing water crisis especially in dry season.

Because of rapid urbanization & development of Mega City, Dhaka, the situation has become more challenging to meet the rapidly increasing water demand. So, it is evident that water supply system cannot be improved unless and until the Non-Revenue Water (NRW) is reduced.

DWASA is moving towards environment-friendly, sustainable and pro-people water supply management system. To ensure it, DWASA developed Water Supply Master Plan for Dhaka City in 2014. Following the master plan, DWASA has already started establishing District Metered Area (DMA) concept which is new and innovative in the South Asia Region. Several water treatment plants projects have already been taken with a view to increase dependency on surface water up to 70 percent. 10- Zones of DWASA have been divided into 171 DMAs. So far established 104 DMAs and remaining 67 DMAs are in progress under different projects. The average NRW became around 5% at the established DMAs. Figure 1 shows the DMA status in Dhaka city.

2. Selected Projects for DMA Establishment

To cope up the challenge to ensure safe water for the city dwellers with customers' satisfaction in terms of water quantity, quality, system pressure; several projects have been initiated by DWASA. After successful completion of the project Dhaka Water Supply Sector Development Project (DWSSDP), DWASA introduced another two projects, Dhaka Environmentally Sustainable Water Supply Project (DESWSP) in 2013 and Dhaka Water Supply Network Improvement Project (DWSNIP) in 2016 to establish the DMAs around Dhaka city. Expanded Dhaka Water Supply Resilience Project (EDWSRP) has been initiated from 2024 to establish remaining DMAs in Dhaka city with the financial support of New Development Bank.

(1) Dhaka Water Supply Sector Development Project (DWSSDP)

Dhaka WASA implemented the DWSSDP with financial assistance from Asian Development Bank (ADB) & Government of Bangladesh (GoB) and it was initiated in 2011. The project ensured sustainable, reliable and improved water supply services through strengthening distribution networks shifting the house connections

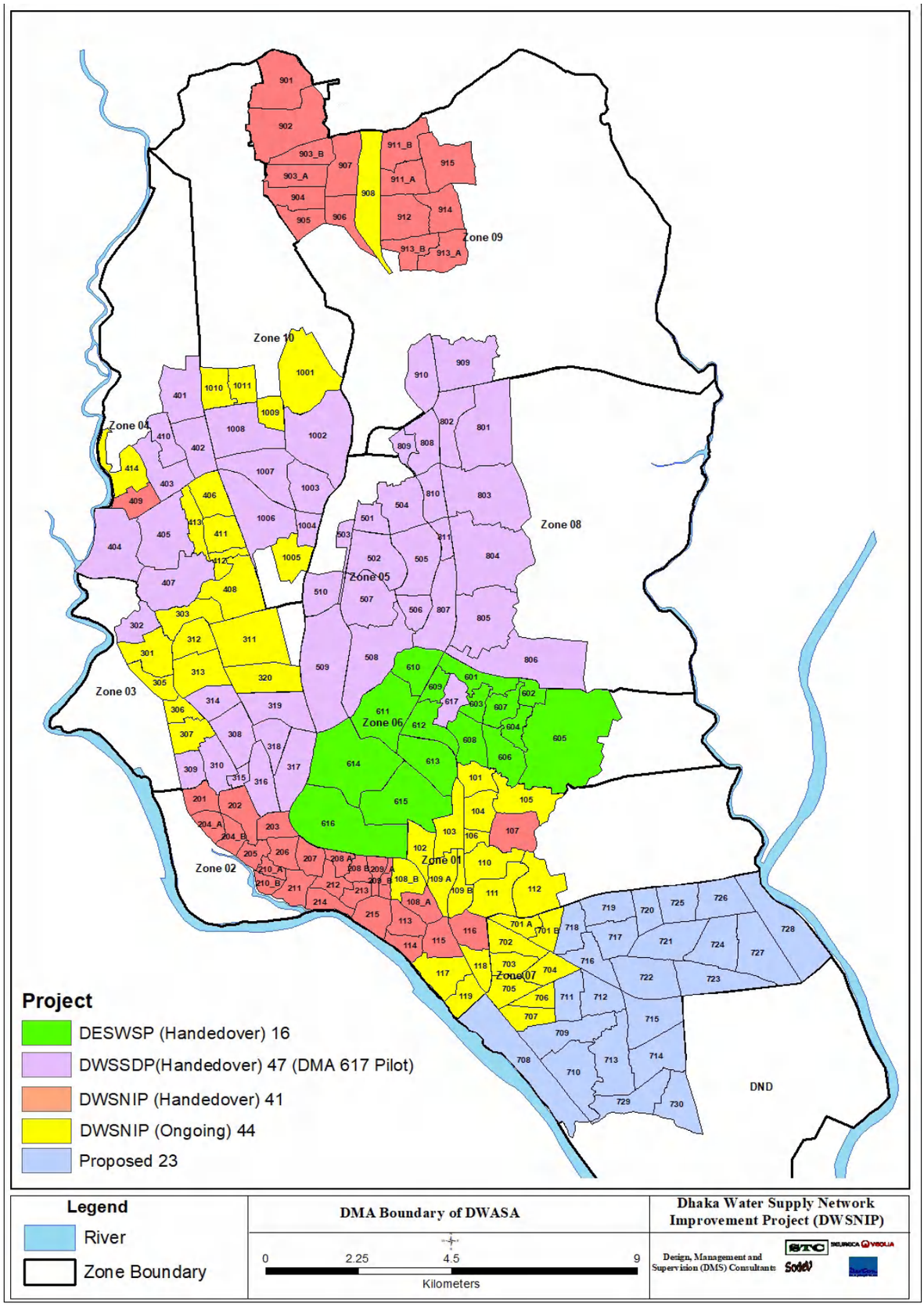


Figure 1.1 District Metered Area (DMA) status in Dhaka city

from old network to new one and capacity building for better operation & management of the network by introducing of District Metered Areas (DMAs). Under DWSSDP, a total of 47 numbers of DMAs were established in 6 MODS Zone of DWASA. In the project total 2456 km of water line was rehabilitated and 1,06,662 numbers of house connection were shifted. 5.4 million people are getting benefit from the project.

(2) Dhaka Environmentally Sustainable Water Supply Project (DESWSP)

The main objective of this ongoing project is to supply 500 million liter of water per day from Meghna River. In Gandharbapur, a surface water treatment plant is being constructed. Other components of the project are the development of a water intake at Meghna River, a raw water transmission pipeline, a treated water transmission pipeline to the existing water supply network, and distribution reinforcements. The project also includes distribution network improvements to reduce nonrevenue water (NRW); and already implemented 16 DMAs. In the project total 497 km of water line was rehabilitated and 37,059 numbers of house connection were shifted. Asian Development Bank (ADB) & Government of Bangladesh (GoB) are providing financial support for implementation of this project.

(3) Dhaka Water Supply Network Improvement Project (DWSNIP)

The aim of this ongoing project is to contribute for sustainable provision of a more reliable, improved and climate resilient supply of water for 6.5 million dwellers in Dhaka City, by rehabilitating and strengthening the distribution network, enhancing sustainable DMA management capacity and quality service delivery capacity based on the long-term policy and investment roadmap. Asian Development Bank (ADB) & Government of Bangladesh (GoB) are providing financial support for implementation of this project. Out of total 85 DMAs, 42 DMAs were handed over to DWASA zones for operation and maintenance purpose. 80 to 90% works have been completed in the remaining DMAs. Under the project so far 1628 km of water line was rehabilitated and 1,31,220 numbers of house connection were shifted.

3. District Metered Area

DMA is a technical term to define a hydraulically isolated small area from big network system with its own water supply system and distribution network for a community which can be isolated from remaining network without affecting supply system of other areas but with facilitating surplus water to adjacent water deficit areas. The District Metered Area (DMA) program plans to rehabilitate and replace the existing distribution network. DMA is designed to be a 24-hr pressurized system that will source water from local DTWs and SWTPs i.e. conjunctive usage (DWASA, 2014). For implementation of a DMA, initially the DMA area is surveyed and based on the survey information DMA boundary is selected. After pipe laying pressure test is conducted through data-loggers. Then Pre-commissioning and Commissioning are carried out for establishing the DMA. Different steps for DMA establishment have been described below:

(1) Criteria for selection of the DMA boundaries

Criteria for selection of the DMA boundaries are:

- Selection of area for establishment a DMA
- At least one or more Deep Tube well (DTW) with in the DMA
- Surveyed and Model designed for selected DMA
- Rehabilitate the existing whole network by High Density Polyethylene (HDPE) pipe.
- Upgrade the pumping station.
- All illegal house connection must be legalized.

(2) Survey Equipment

Some survey equipments are used to locate utility lines before pipe laying work to avoid damage to necessary utilities and to determine a safe and easy path to do trenchless pipe installation. Usually, the following equipments are used for survey purpose:

- Ground-penetrating radar (GPR)
- Total Station
- Levelling Machine

(3) Pipe Laying Method

Usually, three methods are followed for pipe laying:

- Horizontal Directional Drilling (HDD): underground pipes are installed through trenchless methods.

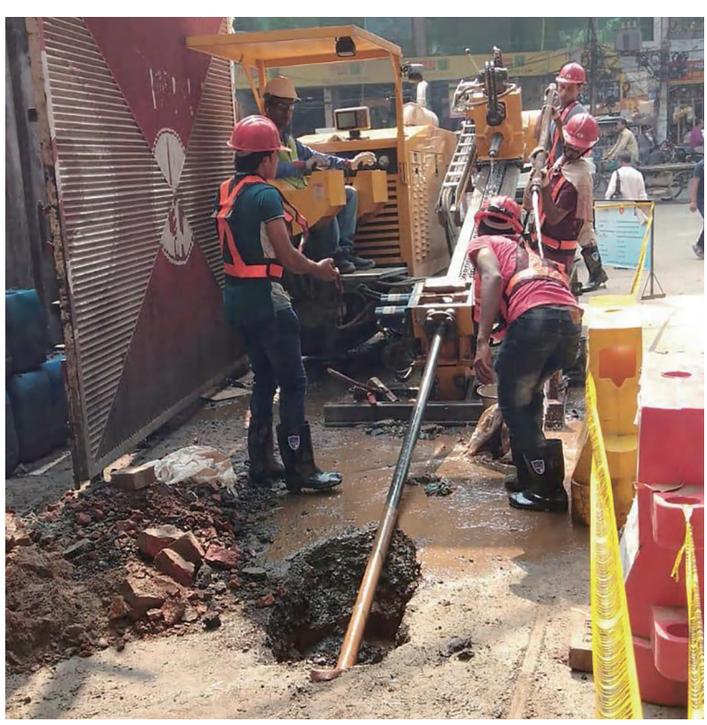


Figure 3.1 Horizontal Directional Drilling (HDD) method

- Pipe bursting: It is also a trenchless method of replacing the buried water pipelines without the need for a traditional construction trench. "Launching and receiving pits" replace the trench needed by conventional pipe-laying.

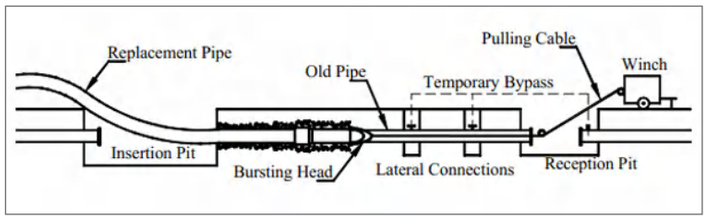


Figure 3.2 Replacement of Bursting Pipe without Construction Trench

- Open cut: It is a common technique for pipeline construction which involves opening up the surface of the ground, excavating down to the required depth through constructing a trench where the new pipe is to be laid.

Figure 3.3 Open cut method

(4) Pipe Jointing Method

There are several technologies for pipe jointing purpose. Among them two methods are frequently used:

- Butt-fusion: This method is used to join pipes without any additional fittings. Wider range of pipe sizes from 50mm to 2000mm can be joined by butt fusion method.
- Electro-fusion: Electro-fusion is a method of joining HDPE, MDPE and other plastic pipes using special fittings that have built-in electric heating elements which are used to weld the joint together.

Figure 3.4 Butt fusion method

Figure 3.5 Electro-fusion method

(5) Pressure Testing

Data loggers serve the purpose of recording pressure and flow data within a DMA network. Electronically it stores raw data, enabling efficient retrieval and subsequent analysis.

Figure 3.6 Pressure testing through Data logger

(6) DMA Pre-Commissioning

During DMA pre-commissioning, water pressure is raised up to 60m (6 bar) for two hours to identify the leakages in the isolated network. The identified leakages are repaired. Physical leakage is ensured to be less than 10%.

(7) DMA Commissioning

DMA commissioning is the process of assuring that all systems and components of a DMA are designed, installed, tested & operated according to the operational requirements. DMA commissioning criteria is to ensure a minimum pressure of 10 m (1 Bar) and physical leakage to be less than 10%.

(8) Advantages of DMA

The amazing achievement of established DMAs is becoming a great focus to the customer and Dhaka WASA management. The specific advantages have been listed below:

- Pressurized water supply is maintained in the DMA area for 24/7.
- All illegal house connections are legalized at the initial stage of DMA establishment.
- Average Water loss (NRW) has been reduced up to less than 5%.
- As water leakage is addressed, chance of water contamination is reduced and supply of potable water can be ensured. In this way, health cost is decreased at the consumer level.
- Water scarcity is not observed in DMA areas. As a result, suction pump is not required and electricity bill of the consumers is reduced.
- DWASA Revenue is increased because of ensuring the legalized connections.
- Water Supply provided in Low Income Community (LIC)/Slum Area in a systematic manner.
- Easy operation & maintenance can be ensured in the DMA area.

4. Challenges of District Metered Area

Dhaka WASA expressed that next challenge would be to sustain DMA Management in order to keep low NRW in established DMAs. DWASA has developed a software named Sustainable DMA Management Tools (SDMT) to ensure sustainable DMA management. SDMT is a web-based software that runs on a server while users connect to it from their computers using an internet browser. Users don't have to install anything, download any software, or worry about upgrades. SDMT is accessible from anywhere via www.dwasacbs.com, as long as the user is connected to the internet; which gives him the opportunity to work on the move from home or from any remote location. Some important features regarding SDMT have been provided below:

- NRW for every DMA can be automatically calculated through SDMT. To calculate NRW for a DMA, volume of supplied water and billed water for that DMA is needed. SDMT calculates the volume of billed water for each DMA from the MIS database.

- DMA Caretaker Team takes production tube well reading, and imports and exports reading for every DMA Chamber through a mobile application (SDMT Data Collection App). This data is then transferred to SDMT.
- SDMT Data Collection App is mobile based and can be used in any mobile operating system. Users registered with the SDMT with special permission can access this application. This application has been designed to work offline which will be connected with the SMDT server when online. Therefore, the DMA Caretaker Team will not require an active internet connection at the time of working in the field.
- In a separate interface of SDMT, DMA Managers can calculate the NRW of their respective MODS Zones by just clicking a button against the DMA. It takes less than 30 seconds to complete the process and store the calculated information. After that, the result is automatically shown in a separate NRW dashboard.
- SDMT enables the users to perform queries on the existing DMA assets (i.e., valves, pipelines, PTW, DMA chambers, service connections, transmission lines, injection points). It also enables the users (selected ones) to modify the attribute of DMA assets, change their location, edit the geometry, or delete the asset. All the updated information is available to the users instantly.

5. Concluding Remarks

In the DMA area the existing distribution network has been rehabilitated to reduce the non-revenue water (NRW). As the DMA is extensively metered to monitor the network status, leakage can be identified easily and proper measures can be taken instantly. In the established DMA areas average Non revenue water (NRW) became less than 5% to 10% from 40%.

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Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

South Asia

India

The Energy and Resources Institute
(TERI)

1. Introduction

(1) State of Water Resources in India

Water sector in India faces significant challenges due to various factors including continual rising and competing demand, overexploitation & inefficient use, pollution, as well as additional risks due to impact of climate change. The declining per capita water availability (from about 5,177 m^3 in 1951 to about 1486 m^3 in 2021) has lead India to be categorised as water stressed.

A government report (2018) suggests that more than 600 million people are facing high to extreme water stress in the country. India's water demand is expected to grow to 1,500 bcm (by 2030) while the current supply is only about half (viz., 744 bcm). A large amount of water used in the agriculture sector in India comes from the groundwater sources. Out of 6607 administrative units (Blocks/ Taluks/ Mandals/ Districts) assessed (in 2011) for groundwater in India, about 16.2% (1071 units) stands overexploited, 3.3% (217 units) are in critical state while about 10.5% (697 units) remain semi-critical. Despite an increasing water demand, the water use in different sectors remains inefficient. Agriculture sector that consumes more than 80% of India's water resources has a considerably low overall average water use efficiency (about 38%). Compared to international standards, Indian industries consume relatively higher amount of water for production. The water supply and distribution in most of the Indian cities have significant leakages/losses and high non-revenue water (NRW). Furthermore, pollution of many Indian rivers and lakes due to discharge of untreated or partially treated sewage and industrial wastewater, continues to be a challenge. Of the estimated 72368 MLD sewage generated (from class I cities and class II towns in India, the existing operational treatment capacity of STPs is about 26869 MLD (37%), while the actual utilization of the capacity is about 20235 MLD i.e. 27.96% of total sewage generated. (CPCB, 2021). The multiple stress on water resources are further expected to be exacerbated by the impacts of climate change.

(2) Initiatives by Government of India

The Government of India has initiated various large scale programs and schemes from time to time to address the mentioned challenges related to water. The "National Water Mission" under the Ministry of Jal Shakti, Govt. of India has set up specific goals that emphasizes the need for increasing the water use efficiency (by 20%), promotion of water conservation, focus on over-exploited areas, wastewater recycle and reuse, minimizing wastage and ensuring equitable distribution both across and within States through integrated water resources management (IWRM). Several nationwide major initiatives have been undertaken such as the "Jal Jeevan Mission" to provide potable water through taps to all rural households by 2024; the "Jal Shakti Abhiyan-Catch the Rain", a campaign focused on rainwater harvesting & water conservation; the "Atal Bhujal Yojna", a program for the proper management of groundwater; Atal Mission for Rejuvenation and Urban Transformation (AMRUT) scheme (2015) focuses on development of basic infrastructure in selected cities and towns in the sectors of water supply; sewerage and septage management; storm water drainage etc. In the agri-irrigation sector, the "Pradhan Mantri Krishi Sinchayee Yojana" scheme focuses to increase the water use efficiency in agriculture/irrigation. Government's flagship program "Namami Gange" (launched in 2014) focuses on cleaning, conservation and rejuvenation of the major river Ganga.

(3) The Energy and Resources Institute (TERI)

TERI, a leading scientific research organisation and think tank in India, engages with several stakeholders including the Central/State Govt., industries, cities and the grassroots, in providing sustainable solutions and policy inputs in various areas such as water use efficiency, water conservation, urban & rural water demand management, IWRM, drinking water & sanitation, wastewater recycle/reuse, climate adaptation & mitigation etc.

2. Selected Key Projects

(1) Jal Shakti Abhiyan - Catch the Rain (JSA-CTR)

a. Description

Ministry of Jal Shakti launched "Jal Shakti Abhiyan" campaign in 2019 focusing on 1,592 blocks in 256 water stressed districts of India. With the tag line "Catch the rain, where it falls, when it falls", the initiative encourages states and relevant stakeholders to create rain water harvesting structures. Since 2021, "Catch The Rain" campaign was subsumed as "Jal Shakti Abhiyan- Catch The Rain" (JSA-CTR) to cover all the blocks of all districts (rural as well as urban areas) across the country and is an annual feature (every year from March to November) that aims to make water conservation a 'jan andolan' (people's movement).

b. Challenges

Several water stressed districts facing water paucity were focused at the start, however, the program could not be implemented in 2020 due to Covid pandemic. Encroachment of water bodies, overexploited groundwater along with declining water availability necessitates the need to renovate the existing structures and create new rainwater harvesting structures.

c. Solutions

The key focused interventions of the scheme included water conservation and rainwater harvesting, geo-tagging, preparation of inventory and scientific plans for water conservation for all the water bodies, intensive afforestation and awareness generation amongst others. Some of the key achievements of this campaign (From 2019 to 2023) are presented below.

Table 2.1 Key achievements of Jal Shakti Abhiyan, (Year 2019 to 2023)

Jal Shakti Abhiyan: Components	Water Conservation & Rain Water Harvesting Structures	Renovation of Traditional Water Bodies	Reuse and Recharge Structures	Watershed Development	Total of Water Related Works	Intensive Afforestation	Training Programmes/ Kisan melas (Farmers Fair)
Total of Completed and Ongoing Works	43,82,621	8,93,373	25,29,647	51,89,605	1,29,95,246	1,35,30,11,139	2,53,942
Total expenditures including water related works and afforestation					INR 1084.11 Billion		

(2) Jal Jeevan Mission (JJM)

a. Description

The Jal Jeevan Mission was launched with an intention of improving the standard of living of all the citizens by 2024 by providing access to water for all. JJM aims to provide functional household tap connections (FHTCs) to all the rural households in the given timeline at the rate of 55 litres per capita per day (lpcd) and of prescribed water quality for long term on a regular basis.

b. Challenges

With nearly 600 million people facing high to extreme water stress, India has been under significant water crisis and with nearly 70% of water being contaminated (NITI Aayog, 2018).

c. Solutions

This Mission was allocated INR 70,000 crore (INR 700 Billion) in the year 2023-24. Till April 2024, Jal Jeevan Mission achieved a milestone of providing tap water to 14.69 crore (146.9 million) rural homes. Apart from the provision of FHTCs, JJM has been able to provide drinking water supply in public institutions such as schools (89%) and anganwadi centers (86%), besides water quality information management through regular testing of water samples as well as digital integration of water quality & quantity data. Several States/Union Territories such as Goa, Arunachal Pradesh, Haryana, Punjab, Telangana, Himachal Pradesh, Gujarat and Mizoram etc. have achieved the status of functional taps in every rural household.

(3) PM Krishi Sinchayee Yojana (PMKSY) (PM Agri Irrigation Scheme)

a. Description

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) (Prime Minister Agri Irrigation Scheme) was launched during the year 2015-16 with an aim to boost access of water on farm and increase cultivable area under assured irrigation as well as introduce sustainable water conservation practices and improve on-farm water use efficiency, amongst others.

b. Challenges

The water use efficiency in agri-irrigation is significantly low in India, especially the application efficiency, majorly due to the methods adopted for irrigating the crops such as flood irrigation. Success of the scheme is critical for the water use efficiency in this sector.

c. Solutions

The PMKSY implemented some of the major initiatives such as Accelerated Irrigation Benefit Programme (AIBP) to extend the coverage of irrigation, and Har Khet Ko Pani (HKKP) (i.e. water to every field). Key solutions/components and the major achievements of the PMKSY since its launch till the year 2022 is presented in Table 2.2 below

Table 2.2 Status of tap water supply in rural homes in India

Sl. No.	Key components of PMKSY	Achievement during 2016-22
1	Accelerated Irrigation Benefit Programme	New irrigation potential of 24.35 lakh hectare
2	Command Area Development & Water Management	Covering of cultivable command area of 16.42 lakh hectare
3	Har Khet Ko Pani- Surface Minor Irrigation	Irrigation potential of 2.58 lakh hectare created
4	Har Khet Ko Pani- Repair, Renovation and Restoration (RRR) of water bodies	Irrigation potential of 0.84 lakh hectare created
5	Har Khet Ko Pani- Ground Water	Command of 69,378 hectare irrigated by ground water.
6	Per Drop More Crop	61.72 lakh hectare has been covered under micro irrigation
7	Watershed Development	14.54 lakh hectare of additional area have been brought under protective irrigation

(4) Namami Gange Programme (National Mission for Clean Ganga)

a. Description

"Namami Gange Programme", a flagship river conservation programme of the Govt. of India launched in 2014 with objectives of effective abatement of pollution, conservation and rejuvenation of National River Ganga. The program is being implemented by National Mission for Clean Ganga (NMCG) under the Ministry of Jal Shakti with an initial budget outlay of INR 20,000 Crore (INR 200 billion). Its twofold objectives include ensuring the abatement of pollution and the rejuvenation of the Ganga River and to uphold minimum ecological flows in the river.

b. Challenges

The pollution of Indian rivers have been persistent problem. Untreated or partially treated municipal sewage and industrial effluents find way to the holy river Ganga. About 46.4% (1369 MLD) of total generated wastewater (2953 MLD) is discharged untreated from 97 Towns along the main-stem of river Ganga (NMCG 2018).

c. Solutions

The vision for Ganga rejuvenation constitutes restoring the wholesomeness of the river by ensuring 'Aviral Dhara' (continuous flow), 'Nirmal Dhara' (unpolluted flow), as well as geologic and ecological integrity. The programme involved implementation of sewerage treatment infrastructure, river-front development, river-surface cleaning, bio-diversity, afforestation, public awareness, industrial effluent monitoring etc. Namami Gange sanctioned 457 projects of about cost INR 38,438 crore (INR 384.38 billion) of which 280 projects have been completed, while the rest are in progress. A total of 198 sewerage infrastructure projects have been initiated with an aim to create and rehabilitate sewage treatment plant (STP) capacity, providing a total of 6,208 MLD capacity, out of these, 111 projects have been completed which has a capacity of 2,844 MLD. Whereas for the industrial sector, clusters of textiles, pulp & paper, tanneries, etc. were identified for setting up of 5 Common Effluent Treatment Plants (with a total capacity of 40.9 MLD) for treating the effluents entering the river Ganges.

(5) Direct Benefit Transfer for Agriculture Consumers in Punjab

a. Description

To address and provide solutions towards three-dimensional interlinked challenge of declining ground water,

increasing electricity consumption and rising fiscal burden of power subsidy on agriculture in state of Punjab, the scheme was launched by Punjab Government in 2018. A World Bank funded pilot of DBTE (direct benefit transfer for electricity) scheme was implemented by TERI (The Energy and Resources Institute) along with its partners (PAU & ITP) to help the Govt. of Punjab and Punjab State Power Corporation Ltd (PSPCL) in three selected feeders to refine the scheme based on the learnings from this pilot for its wider implementation across Punjab. The objective of this scheme was to incentivize farmers for enhancing their groundwater usage efficiency in agriculture by offering financial rewards.

b. Challenges

India's agriculture sector which accounts for nearly 85% of total water withdrawals, grapples with challenges like water scarcity, environmental degradation, and low productivity. Inefficient irrigation practices exacerbate these issues, especially in states like Punjab, where water-intensive crops strain already dwindling water resources.

c. Solutions

A comprehensive package of interventions was designed to reduce water withdrawals through on-farm practices. To showcase the effectiveness of these interventions, demonstration farms were established across different villages, engaging farmers directly in the process. Through the adoption of water-efficient practices such as alternate wetting and drying (AWD), plotting, laser levelling, and the installation of underground pipeline systems, significant water and energy savings ranging from 6% to 30% and 5% to 21%, respectively, for Kharif and Rabi seasons, were achieved as compared to controlled farms. This was achieved in the cultivation of water-intensive crops like paddy and wheat. Farmers received on-field training and experts guidance, empowering them to implement these water-efficient practices on their own farms. The findings underscored the viability of scaling up interventions state wide. Furthermore, farmers participating in the "Paani Bachao Paise Kamao" ("Save Water Earn Money") scheme realized financial gains by embracing these practices, highlighting the dual benefits of environmental and economic sustainability.

3. Details of the "Jal Jeevan Mission (JJM)"

(1) Jal Jeevan Mission

a. Description

The Jal Jeevan Mission (JJM) has been recent flagship programme of India for providing "Tap-water to every rural household by 2024'. It was launched by the government on 15th August 2019 with an intention of improving the standard of living of all the citizens by 2024 by providing access to water for all. JJM aims to provide functional household tap connections (FHTCs) to all the rural households in the given timeline at the rate of 55 litres per capita per day (lpcd) and of prescribed water quality (BIS 10500) for long term on a regular basis. In 2021, government also introduced JJM-Urban to achieve 100% coverage of urban households with tap connections and sewerage systems.

b. Challenges

With declining per capita water availability and nearly 600 million people facing high to extreme water stress,

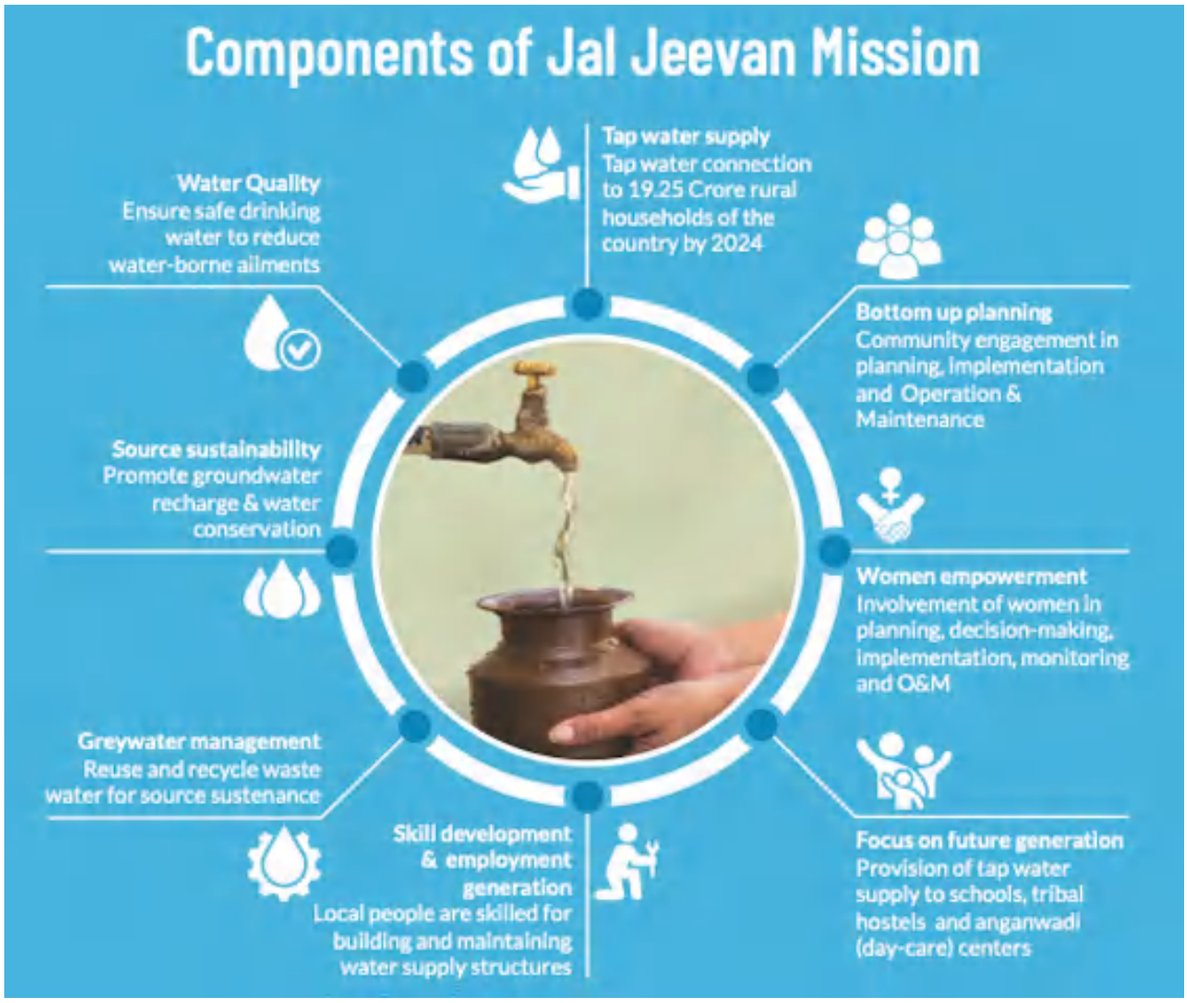

Figure 3.1 Key components of Jal Jeevan Mission (Courtesy: Jal Jeevan Mission, Govt. of India)

India has been under significant water crisis. Also with nearly 70% of water being contaminated, India is placed 120th amongst 122 countries in the water quality index (NITI Aayog, 2018).

c. Solutions

The Jal Jeevan Mission was initiated with aim to provide adequate quantity (55 lpcd) and prescribed quality (as per BIS 10500 standards). JJM was allocated INR 70,000 crore (INR 700 Billion) in the year 2023-24 and INR 70,163 crore (INR 701.6 Billion) for 2024-25. Till April 2024, Jal Jeevan Mission achieved a milestone of providing tap water to 14.69 crore (146.9 million) rural homes. Apart from the provision of functional household tap connections (FHTCs), JJM has been able to provide drinking water supply in public institutions such as schools (89%) and anganwadi centers (86%). Besides this, the mission integrated water quality information management through regular testing of water samples at source and delivery points at about 2124 water testing labs across the country. Further, there have been several digital initiatives for integration of water quality & quantity data (using IoT, SCADA, remote sensing & GIS, etc.). As per the Government data, several States/ Union Territories such as Goa, Andaman & Nicobar Islands, Puducherry, Dadra & Nagar Haveli and Daman & Diu, Arunachal Pradesh, Haryana, Punjab, Telangana, Himachal Pradesh, Gujarat and Mizoram have achieved the

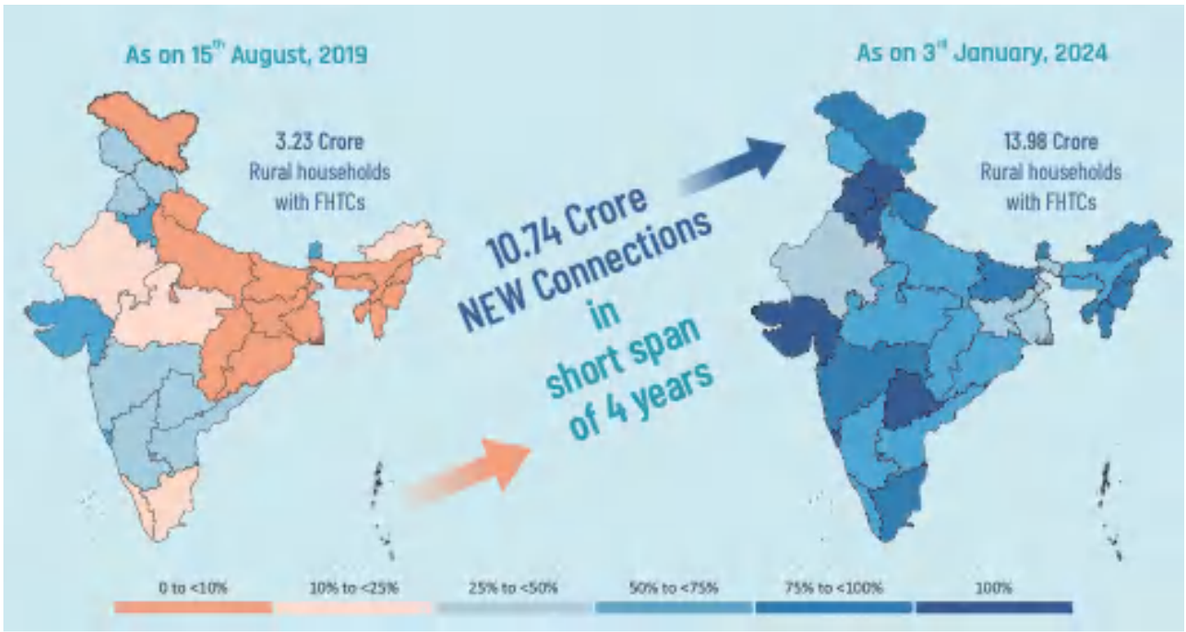

Figure 3.2 Key achievement of the Jal Jeevan Mission (Courtesy: Jal Jeevan Mission, Govt. of India)

status of functional taps in every rural household. In a short span of 4 years (2019-2024) about 10.74 Crores (107.4 million) new FHT connections were achieved. Figure 3.2 depicts the transformation and key achievements during the period.

Table 3.1 Status of tap water supply in rural homes in India (2019-2024)

Total number of households (HHs)	Households with tap water connections (as on 15 Aug 2019)	Households with tap water connections (as on 25th April 2024)
19,30,28,491	3,23,62,838 (16.77%)	14,69,59,087 (76.13%)

- **Enhancement in Water Supply to Households including remote areas:** As on April 2024, the tap water supply in rural households has increased from 3.23 Crore (32.3 million) in 2019 to 14.69 Crore (146.9 million) households. The mission realised a 9-fold increase in functional household tap connections FHTCs in 112 remote and socio-economical backwards districts from 21.42 lakh to 196.56 lakh. It also achieved an increase in FHTCs from 8.02 lakh to 210.69 lakh in 61 districts affected by Japanese Encephalitis/ Acute Encephalitis syndrome. Besides these, 9.24 lakh schools, 9.57 lakh anganwadi (day-care) centres and 3.89 lakh public institutions were benefitted as well. More than 5.17 lakh Village Action Plans were developed including O&M and source sustenance.
- **Water Quality Management, Community Engagement and Women Empowerment:** JJM provides a network of about 2,113 water testing laboratories across the country that allows the public to test water samples at nominal rates. More than 23.55 lakh women have been trained under the program to use Field Test Kits (FTKs) to check the quality of water supplied at source or delivery point at home. JJM also provided for community engagement of about 5.29 lakh Village Water and Sanitation Committees with at least 50% women.

4. Future Plan

(1) Moving Towards Sustainable, Efficient & Water Secure Future

The road to sustainable water use and water security has to be carved through integrated water management, involving a framework of innovative solutions, progressive policies and sustainable use of water resources with participatory planning and regular stakeholder engagement. The development challenges are expected to increase in coming decades and are expected to be aggravated by impact of climate change. India aims to follow a development pathway to become Net Zero by 2070 and in doing so role of climate resilient water management with adequate adaptation and mitigation options will play a key role.

While striving for successful completion and continuation of flagship program and initiatives on water such as Jal Jeevan Mission, Namami Gange, PMKSY, AMRUT (Atal Mission for Rejuvenation and Urban Transformation), Atal Bhujal Yojna etc., India would look towards an integrated water management strategy which optimizes efficient use of water, improves water productivity, reduces losses, and promotes water conservation interventions in all its sectors i.e. irrigation, domestic and industrial water sectors. This includes the integrated river basin and watershed management approaches for holistic solutions. With setting up of the National Bureau of Water Use Efficiency (NBWUE) under the National Water Mission, India looks towards enhancing and promoting collective action towards national goals on water sustainability, water use efficiency, urban and rural water service delivery, water conservation, wastewater recycle/reuse and circular economy, while simultaneously aligning with the international commitments on SDGs (Sustainable Development Goals)(SDG-6), Nationally Determined Goals (NDCs) under climate action as well as Net Zero pathways.

Through its "Mission LiFE (Lifestyle for Environment')" approach India looks towards nudging individual and collective action towards sustainable 'Lifestyle for Environment' which amongst others emphasises on water saving habits and practices for water use and management.

TERI looks forward to continue contributing and expanding its work with wider range of stakeholders through innovative solutions, technologies and policy support to bring about the transformative changes towards efficient & sustainable use of water resources in India.

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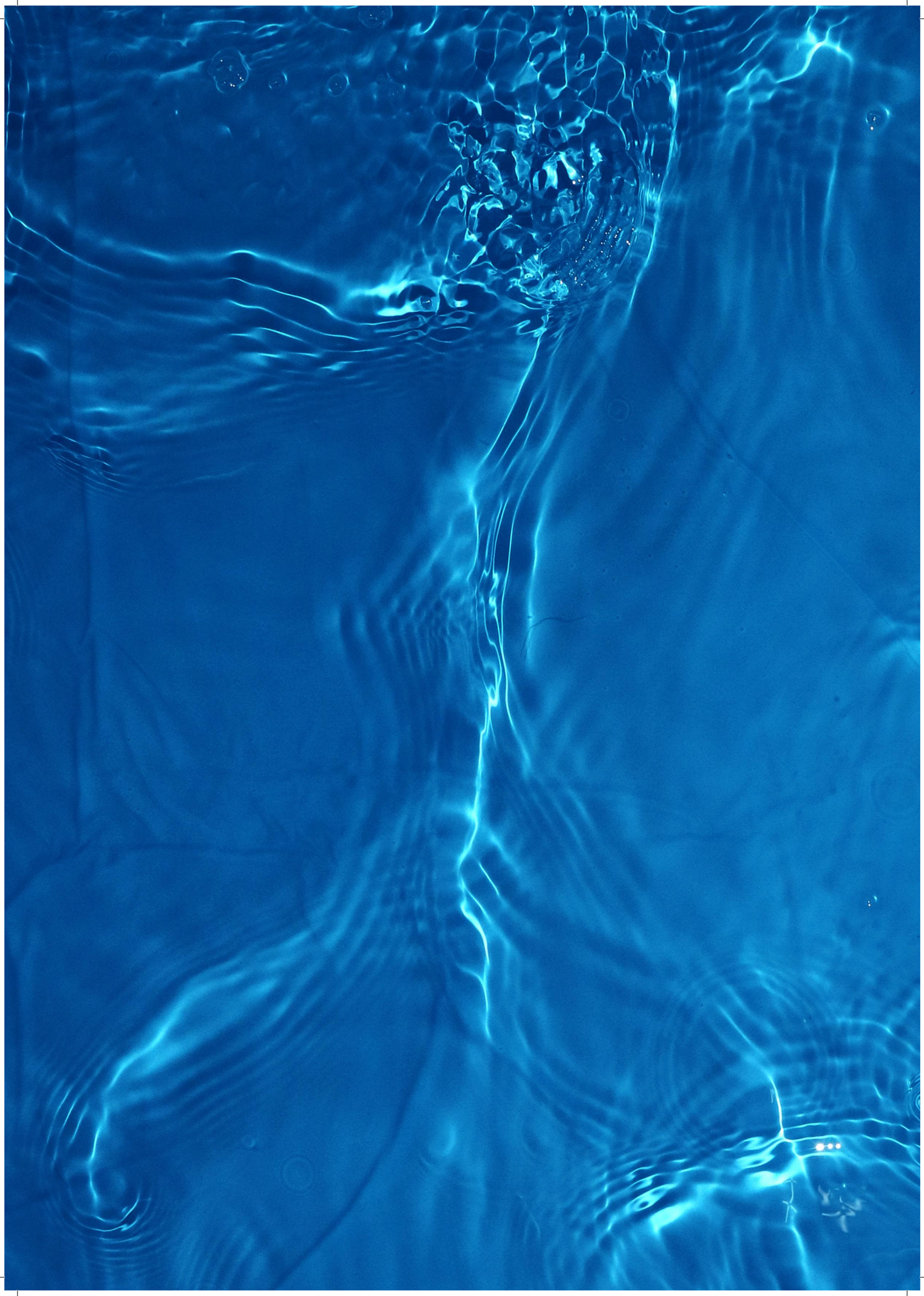


Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

South Asia

Nepal

SMART WASH Solutions

1. Introduction

(1) Water Resources in Nepal

Nepal is rich in water resources. There are about 6,000 rivers in Nepal with a drainage area of 191,000 sq. km, 74 % of which lie in Nepal alone. The surface water available in the country is estimated to be about 225 billion m^3 (BCM) per annum or equivalent to an average flow of 7,125 m^3/s, out of which only 15 BCM per annum is in use. Around 95.9% of 15 BCM has been used for agriculture, 3.8% for domestic purposes, and only about 0.3% for industry. While water demand is increasing significantly in urban areas, excess water causing floods, landslides, GLOF (glacial lake outburst flood), and soil erosion have led to destructive impacts in Nepal.

The estimated hydropower potential of Nepal is 83,000 MW, of which 114 projects with 45,610 MW have been identified as economically feasible. At present, the Nepal Electricity Authority (NEA) has a total installed electricity generation capacity of around 2857 MW, and around 95% of the country's total population has access to electricity. The Government aims to produce over 28,000 MW of electricity by 2035, but that requires massive resources. Around 97% of the country's population has access to basic water supply, but only 27% of the population has access to safe water supply. Agriculture is an important part of the Nepali economy and social fabric, contributing an estimated 24% of the GDP in 2023 and providing employment to more than 60% of the labor force. Approximately only 40% of the total agricultural areas (35, 57,000 ha) are irrigated. Agriculture, particularly irrigated agriculture, is facing several challenges and has considerable potential for improvement and expansion.

Climate change impacts are observed in several sectors of Nepal, among which water resources is one of the hardest hit sectors. Studies have shown that the impacts of climate change have caused water stress during this century and will influence water resource availability in the future (Gurung et al. 2019; Dahal et al. 2020). The situation of scarce and excess water, already persistent, is exacerbated by climate change with changes in monsoon patterns and temperature. The average annual maximum temperature of Nepal has increased by 2.4 °C (0.056 °C/year) over the 44 years from 1971 to 2014 (DHM 2017). Precipitation has also become more variable, with an increase in extreme precipitation events (Karki et al. 2017), while the mean rainfall has been decreasing by 3.7 mm (−3.3%) per month per decade (GoN 2017), indicating more droughts and depletion of water resources. Although Nepal has emphasized the concept of Integrated Water Resources Management (IWRM) in its National Water Resources Strategy, National Water Plan, and other water-related policies, it still lacks a proper institutional arrangement and plan implementation framework to address IWRM across the water resources sector. As a result, Nepal's effort to address several water-related challenges, including water scarcity, deteriorating water quality, and water-induced disasters, remains futile.

2. Selected Completed Projects

(1) Rasuwagadhi Hydropower Company Limited Rasuwagadhi Hydroelectric Projects

a. Description

Rasuwagadhi Hydropower Company Limited (RGHPCL) is a public limited company established in August 2011 AD to harness the hydropower potential at a reasonable rate with the full utilization of the national resources available in the country. Rasuwagadhi Hydropower Company Limited started to develop the Rasuwagadhi Hydroelectric Project, which has a capacity of 111 MW, in the middle of 2014 and now all the construction work activities of the project have been completed and are ready for power generation. The project is located in Rasuwa district of Bagmati province, Nepal. The project is a run-of-river type with a design discharge of 80 m^3/sec and a gross head of 168m. The source river is Bhotekoshi (Trishuli) which flows down from Tibet, China entering Nepal at Rasuwagadhi and reaches down to Trishuli in Rasuwa district. The headworks of the project comprise a non-gated diversion weir having a crest length of 61.50m, two bays under a sluice with a radial gate, a side intake having three bays with trash racks followed by three pressure conduits, and three desander intake tunnels. The underground powerhouse accommodated three units of generating equipment with vertical axis Francis turbines.

b. Challenges

- A high-impact earthquake occurred on 25 April 2015 with a magnitude of 7.8 Mw that totally disrupted the work activities of the project due to the loss of lives, equipment, and materials and heavily damaged the infrastructures, which forced the project work to stop for a long time.
- The project areas and public road up to the project site where the landslides occurred during the earthquake were heavily affected during the rainy season, causing flash floods, heavy landslides, and rock avalanches to frequently occur in the project area which has forced stop the project works in a long time.

c. Solutions

- Continuous joint coordination meetings were organized between the parties, the Employer, Engineer, and the Contractor to resume the work activities of the project as soon as possible.
- Joint efforts were provided to minimize the monsoon effects in the project areas and public roads in coordination with the concerned authorities.
- Repair, maintenance, and rehabilitation work caused by the force majeure issues were performed by the concerned parties as per the contractual provisions mentioned in the contract.
- Finally, the Project has been completed by fulfilling the contractual obligations and responsibilities between the parties.

(2) Urban Water Supply & Sanitation Project (UWSSP)

a. Description

Urban Water Supply and Sanitation (Sector) Project (UWSSP), funded by the Government of Nepal (GoN), Asian Development Bank (ADB), and the Water Users Association (WUA)/Water Users and Sanitation Committee (WUSC)/ Municipality started its activities on January 11, 2019 and will continue till the end of April 2025. Total Project cost is US$ 137.20 Million (ADB Loan: US$ 100.00 Million & GoN/ WUA: US$ 37.20 Million). In this project, there are 24 water

subprojects located throughout Nepal. Of the total 24 subprojects, 20 are water supply improvements, two are decentralized wastewater treatment systems, one is stormwater drainage, and another is fecal sludge management/ stormwater drainage type.

b. Challenges

- The UWSSSP is facing the following challenges:
- Poor work performance of Contractors
- Poor resource management by Contractors
- Land availability for Structures site change during implementation

c. Solutions

- Well-trained permanent engineer deployed in site offices
- Continuous joint coordination meetings are being organized to resolve raised Issues
- Frequent monitoring visits to the projects by WUSC, Municipality, R/PMO, RDSMC, and PMQAC experts.

(3) Rani Jamara Kulariya Irrigation Project (RJKIP)

a. Description

RJKIP is the largest irrigation system owing to its construction and management by farmers utilizing the water from Jharahi, one of the distributary of the Karnali River in the far western province of Nepal. In earlier times, three different systems, namely Rani, Jamara, and Kulariya irrigation systems, were developed by farmers in different periods from 1839 to 1858. With the governmental interventions, three different systems were integrated into a single multipurpose project, providing the irrigation facility for 38,300 hectares of land after improvisation to existing systems and producing 4.71 megawatts of hydroelectricity utilizing the head difference of intake and command area. The project is one of the national pride projects out of six others in the irrigation sector and is funded jointly by the government of Nepal and World Bank.

b. Challenges

The major challenges include the modernization of a quite an aged beauty i.e. irrigation system to integrate and accommodate larger command area in the region. The other challenge included the maintaining the water level in the Karnali River to augment the water to the canals throughout the year. Similarly, the level difference of the command area and intake was another challenge to make the system durable, sustainable and have hassle free operation and maintenance.

c. Solutions

- Construction of common side intake for all three systems in the Karnali River and de-silting basin. The size of the canals was increased to accommodate a large command area. This includes the construction of Lamki Extension to accommodate an additional 6,000 ha, and an additional 18,000 ha in between Pathraiya Kandra river, making it a total of 38,300 ha. As of now, the irrigation service has been provided on 25,300ha of agricultural land.
- Several programs were launched to increase the awareness of the farmers, convince them to acquire land, and increase the size of the canal, Agricultural training was provided to the farmers to increase agricultural productivity, including training on the operation and maintenance of the canal.

- The energy of the water due to the level differential between the intake and command regions was dissipated by the construction of the powerhouse between the intake and command areas. The powerhouse's installed capacity is 4.71 megawatts.

(4) Automation Mulpani Sankhadevi Water Supply and Sanitation Project

a. Description

Mulpani Sankhadevi Water Supply and Sanitation Users Committee provides water supply to 900 consumers since November 27, 2016. Before establishment of water user committee most of the water users were depended on traditional stone spout, open well, etc. From the financial and technical support of Federal Government of Nepal, the water supply system was constructed. The objectives of the water user committee are to improve the access of safe drinking water and to ensure the continued supply and to improve the public health by the reduction of water borne diseases. The initial management of water supply system was based on manual operation of pump, billing, accounting and asset records.

b. Challenges

Before the installation of Internet of Things (IoT) technology and the account management system of Mulpani Sankhadevi Water Supply and Sanitation Project, the key challenges they were facing in the absence of digitalization and automation of the system were as follows:

- Limited Visibility and Monitoring mechanisms
- Inadequate data information, acquiring data and its management
- Inadequate transparency due to lack of enough data and information
- Accurate data was not available, resulting in a delayed decision-making process
- High operation and management costs, and
- Insufficient records of asset and its location.

c. Solution

The following Internet of Things (IoT) based technology for control water management and WaterMark Software were installed by the water users committee to address the challenges.

- Hydrostatic level sensor: Commonly known as water tank sensor, it is used for automating pump operation.
- Remote Terminal Units: The devices were used to manage communication between the sensor and cloud-based server to control the operation of the system and data transformation. It also provides system security and control of functions.
- GIS mapping and asset records: The GIS mapping and asset record covered the asset information, location aging report, problematic areas like tariff collection, damages issues, etc.
- Revenue Management System: The system covers meter reading, billing, and accounting. It generates daily reports, tariff collection reports, due reports, advance payment reports as well as journal vouchers and balance sheets. The system also has facilities for an online payment system.

(5) Preparation of River Basin Plans and Hydropower Development Master plan and Strategic Environmental and Social Assessment

a. Description

The government of Nepal approved the Water Resources Strategy (WRS) in 2002 and the National Water Plan (NWP) in 2005. The NWP focuses on the implementation of activities based on the principles of integrated water resources management (IWRM). The four objectives of the study are:

- Preparation of River Basin Plans
- Preparation of Hydropower Development Master Plan
- Strategic Environmental and Social Assessment
- Capacity Building of related government institutions

b. Challenges

In order to maintain a balance between competitive uses and the distribution of water, there is a need to prepare river basin plans. In the present federal context, the sharing and distribution of water resources among different provinces and local bodies have increased needs urgently. A need has been felt by the government to prepare detailed river basin plans as well as the hydropower master plan for future project implementation.

c. Solutions

- Final reports on the River Basin Plan (RBP), Hydropower Development Master Plan (HDMP), and strategic environmental and social assessment report are prepared.
- Supporting technical notes and report annexes containing key resources planning information.
- A fully functional and accessible database is operational on the WECS websites.
- Training to relevant government agencies.

(6) The Beacon Project support for safe WASH for Dalit and Disadvantage People

a. Description

The Beacon Project is a collective effort to create reliable and sustainable 24/7 water supply and sanitation services in a municipality of more than 100,000 people in Lahan Municipality. The project has been regularly supported since 2017 and is committed to supporting up to 2030 with annual planning support of around 500-600K GBP for municipal-level WASH services in municipalities, including Nepal Water Supply Cooperation. The project is a multi-stakeholder partnership through which we strive to be a model of best practices for delivering water, sanitation, and hygiene (WASH) in Nepal and beyond. The project is supported and funded by Anglian Water, a UK water utility, and its supply chain partners. Funds are raised for the project through charitable events, and technical advice is provided through exchange visits and online meetings. In Nepal, our partners are the Nepal Water Supply Corporation (NWSC), the Ministry of Water Supply (MoWS) and Lahan Municipality. WaterAid staff in Nepal and the UK work as advisors and facilitators for The Beacon Project.

b. Challenges

- The project is a multi-stakeholder project and needs clear communication among the three tiers of government.
- Matching funds from project and government organizations needs rigorous follow-up
- NWSC has 22 similar branch offices with more than 200K users and needs to develop its business plan.
- Local government needs technical expertise in Water utility management

c. Solutions

- The project outcomes can be extended under "Legacy that Grows" to replicate the business model of Water utility at both the provincial and federal levels of government
- Regular monitoring and evaluation from all layers of government is needed for sustainable water utility.
- Adequate financial resources from the local government and a clear WASH plan at the local level can solve the issues and provide a safely managed water supply system for dalit and marginalized communities

3. Detail of the "Urban Water Supply & Sanitation Project (UWSSP)"

(1) Description

Urban Water Supply and Sanitation Project (UWSSP) funded by Government of Nepal (GoN), Asian Development Bank (ADB) and Water Users Association (WUA)/Water Users and Sanitation Committee (WUSC)/Municipality started its activities from 11 Jan 2019 and will continue till the end of April 2025. The Ministry of Water Supply (MOWS) is the Executing Agency (EA). The Department of Water Supply and Sewerage Management (DWSSM) under the Ministry of Water 4Supply is Implementing Agency (IA) and has established the Project Management Office (PMO) for the UWSSP.

Total Project cost is US$ 137.20 Million (ADB Loan: US$ 100.00 Million & GoN/ WUA: US$ 37.20 Million). In this Project here are 24 water subprojects located throughout Nepal. Of the total 24 subprojects, 20 are water supply improvements, two are decentralized wastewater treatment systems, one is storm water drainage and other one is fecal sludge management/storm water drainage type.

Outcome by 2024 (revised 2025): Inclusive and sustainable access to WSS services in project municipalities will:

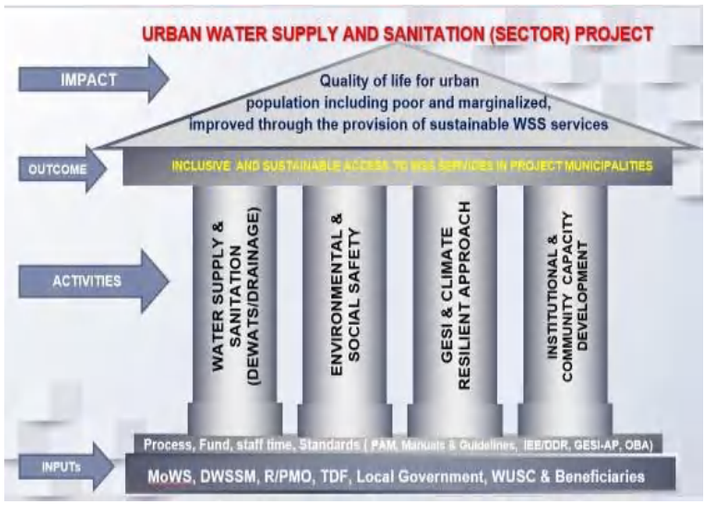
a. Benefit Population:

320,000 people (including all poor and vulnerable) in project municipalities have access to 24/7 piped water supply at 100 lpcd, meeting National Drinking Water Quality Standard 2079 (revised _NDWQS).

b. Improve Sanitation facilities:

64,000 people (including all poor and vulnerable) in project municipalities have access to improved sanitation facilities.

Overview of the UWSSP is as follows: Elapsed time is 79.82 % and overall progress of the UWSSP is 83.42 %. Of the 24 civil contracts, 12 are in the DLP, two are in the O & M. One subproject-Diktel has completed DLP and moved towards contract closure and 10 are under implementation.



(2) Challenges

The UWSSSP is facing following challenges:

- Poor work performance of Contractors
- Poor Resources Management by Contractors
- Land availability for Structures – Site change during implementation
- House Connection Issue – Incompatibility of contract target with user's contribution
- Delayed payment by Municipality in Drainage/DEWATs subprojects
- Delayed assessment of variation
- Lagging in proper sub-project management; Performance of Consultants
- Third Party Damage and its Correction
- Scarcity of budget for Plumber Training (GESI-AP)
- Delay in removal of electric poles
- Road cutting halted by Department of Roads (DoR)

(3) Solutions

- Well trained permanent engineers are deployed in site offices
- Contractors are observed not paying attention to adequate resource management
- Contractors must work at different fronts with sufficient labors, construction materials and equipment and with higher efficiency and management. They need to revise the schedule to accommodate progress lag
- Frequent coordinative meetings with all concern stakeholders for enhancement in progress and settlement of any issues
- Frequent monitoring visits to the projects by WUSC, Municipality, R/PMO, RDSMC and PMQAC experts.

4. Future Plan

(1) Challenges on Water Resources and Energy due to climate change

Studies have shown that the impacts of climate change have caused water stress during this century and influenced water resource availability in the future (Gurung et al. 2019; Dahal et al. 2020). The situation of scarce and excess water, already persistent, is exacerbated by climate change and changes in monsoon patterns and temperature. A study conducted by ICIMOD reveals that 50% of spring sources in the Mountain region are drying out, resulting in the poor functionality of water supply systems. In addition, climate-induced disasters have increased the frequency of landslides, soil erosion in the hills, and floods and inundations in Terai (Ahmad et al. 2018). There is a lack of a proper institutional arrangement and plan implementation framework to address IWRM across the water resources sector. Rising temperatures cause glaciers to shrink and enhance glacier melt Glacier Lake enlargement creates GLOF risk. Changes in precipitation pattern (high-intensity rainfall, number of rainy days decreasing in monsoon and non-monsoon seasons). Excess water in high flow and insufficient water in low flow for energy production from Run-of-Rivers projects.

(2) Future Action

To address and overcome impact of climate change on the water resources and energy sector of Nepal requires a multi-faceted approach involving government policies, green infrastructure development, community involvement, and sustainable practices. Future actions to be taken are as follows:

1. Food Security to alleviate hunger, improve irrigation facilities for all agricultural land, and provide year-round irrigation services (conjunctive use of surface and groundwater, improvement of water use efficiency).
2. For energy security, promote renewable green energy production for domestic use and fossil fuel replacement and hydropower production for domestic, industrial, and transport use to minimize the import of petroleum products and export excess energy to reduce trade balances with neighboring countries.
3. For disaster risk reduction, protect developed infrastructure by focusing on risk assessment and reduction activities, developing preparedness plans and early warning systems, and making infrastructure resilient to climate change.
4. Water Conservation and Management: Implement water conservation measures such as rainwater harvesting, groundwater recharge, and efficient techniques to optimize water usage.
5. Implementation of sustainable integrated water resource management (IWRM) for multiple uses of water as a nexus approach and ensuring stakeholder participation to protect people and the environment.
6. Establishment of a smart water management system from source to endpoint to minimize leakages, improve quality monitoring, and reduce operation costs for efficient and cost-effective management of the systems.
7. High priority for the development and implementation of water sector projects based on the river basin plan and hydropower development master plan recently prepared by the Water, Energy, and Commission Secretariat

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Insight into Asian Water Vol. 2 (2024)

Asian Water through Country

South Asia

Pakistan

Gomal Damaan Area Water Partnership
(GDAWP)

1. Introduction

Water is a vital resource for sustaining life, ecosystems, and economic activities. In Pakistan, a country predominantly agrarian, water holds paramount importance for agriculture, industry, and domestic use. However, Pakistan faces significant challenges concerning water scarcity, contamination, mismanagement, and inefficient allocation. Understanding the sources, issues, and potential solutions is critical for addressing Pakistan's water crisis. Pakistan is facing a worst form of water crisis because of environmental factors like global warming and melting of glaciers. The summers of 2024 are expected to be the worst due to less than average accumulation of ice on glaciers and in northern areas of Pakistan. The seriousness of intra-state water crisis need to be analysed from three angles;

- Water Management Mechanism
- No more ignoring of polarisation and conflict over water management mechanism
- Evolve consensus over construction of Kalabagh Dam which is pending for six decades.

(1) Water Sources in Pakistan

- **Surface Water:** The majority of surface water in Pakistan is provided by the Indus River and its tributaries, the Jhelum, Chenab, Ravi, and Sutlej. The Indus River is the foundation of the country's agriculture.
- **Glacial Melt:** The Indus River System is maintained by the river flows that are produced by the melting of the Himalayan and Karakoram glaciers, particularly in the summer.
- **Aquifers:** Groundwater is essential, especially in arid areas with low surface water supplies. Certain areas of Punjab and Sindh have higher salt levels and falling water tables as a result of over-extraction.
- **Rainfall:** Pakistan's rainfall patterns are not constant, and many regions are experiencing severe droughts. The underutilization of rainwater gathering techniques exacerbates the problem of water scarcity.

(2) Water & Power Development Authority (WAPDA) Contribution to Water Sector

The Water Wing of WAPDA is tasked with the planning, design, and implementation of projects related to water resources development, including irrigation, drainage, and hydropower. It also oversees the operation and maintenance of major surface water projects, including large dams, which are crucial for the nation's economy. Through initiatives like the Indus Basin Replacement Works, WAPDA has completed significant projects such as Mangla Dam (1967), Tarbela Dam (1976), five barrages, and eight inter-river link canals (1965-70). These projects play a vital role in contributing to the national economy. Additionally, WAPDA has undertaken efforts to reclaim 18 million acres of land affected by waterlogging and salinity across the four provinces. This includes the installation of over 15,000 tube wells, the construction of 12,000 km of surface drains, and 13,000 km of tile drains. These projects have been transferred to the respective provinces for operation and maintenance. WAPDA continues to work on various projects in the water and power sectors, demonstrating its on-going commitment to improving infrastructure and addressing challenges in Pakistan.

Water holds paramount importance in Pakistan, intricately intertwined with both federal and provincial governance structures. The Ministry of Water Resources at the federal level plays a vital role in crafting policies, facilitating inter-provincial water agreements, and overseeing key water projects. Similarly, provincial administrations have significant

responsibilities in managing water reservoirs within their jurisdictions, typically through irrigation and agriculture departments. Inter-provincial water disputes, especially concerning the distribution of the Indus River waters, highlight the need for effective coordination between federal and provincial entities. Addressing water scarcity, improving irrigation systems, and addressing climate change impacts require seamless collaboration across all governmental levels. Despite occasional challenges, maintaining dialogue and cooperation between federal and provincial bodies it is crucial for ensuring the sustainable management and equitable distribution of this vital resource nationwide.

In Pakistan provincial Governments are responsible for water and sanitation since 2001 for service delivering to local government. Only small water projects are under taken at provincial level due to lack of finances and capacity. At Federal level it is WAPDA which undertake mega projects.

2. Different Completed Projects of Pakistan

Detail of few projects completed by WAPDA in last 10 to 15 years. A very brief description of each due to limitation of space. Only one project Sadpara Dam will be discussed at length.

(1) Gomal Zam Dam

This multipurpose dam is located in South Waziristan District of Khyber Pakhtunkhwa, aimed at irrigation and flood control. Gomal Zam Dam: Key infrastructure project in Pakistan, providing water storage and hydroelectric power."

(2) Allai Khwar Hydropower

Left bank tributary of Indus River near Besham in District Battagram, Khyber Pakhtunkhwa. A significant hydroelectric facility in Pakistan, contributing to the country's renewable energy capacity and electricity generation, harnessing the power of the Allai Khwar River."

(3) Duber Khwar

Duber Khwar HPP (130 MW) started Commercial Operation in March 2014. A vital hydropower initiative in Pakistan, harnessing the energy potential of the Duber Khwar River to generate electricity and support sustainable development in the region."

(4) Greater Thal Canal Phase-1

Greater Thal Canal having CCA 355,000 Acres was completed in June 2009 and handed over to Irrigation Department, Govt. of Punjab on 30-06-2010. It aimed at enhancing agricultural productivity and water management.

3. SATPARA DAM PROJECT (COMPLETED), PAKISTAN

(1) Introduction and Details of Project

The "Satpara Lake" project in Gilgit-Baltistan, Pakistan, involves the construction of a dam downstream of the lake, enhancing water management in the region. Supported by US funding, the project has benefited over 8,000 farmers, reducing water losses by 60% and expanding cultivable land. Completed in 2013, the dam serves hydroelectric power generation, irrigation, and drinking water supply, addressing water scarcity and fostering socioeconomic development in the area.

(2) Objectives

- **Irrigation:** Providing dependable irrigation water to agricultural areas in the Skardu valley is one of the main goals of the Satpara Dam project. By facilitating crop cultivation, this irrigation water improves agricultural productivity and local residents' access to food.
- **Source of Drinking Water:** Skardu and the surrounding areas are guaranteed a steady supply of drinkable water for home usage thanks to the dam. The local population's quality of life and public health outcomes are enhanced by having access to clean drinking water.
- **Hydroelectric electricity Generation:** The Satpara River's potential is harnessed by the dam to produce hydroelectric electricity. By generating power, the region's energy needs are met, improving energy security and lowering reliance on fossil fuels.

(3) Technical Specifications

Satpara Dam is situated on the Satpara River, a tributary of the Indus River, near Skardu town in Gilgit-Baltistan.

The dam has a storage capacity of approximately 0.058 million acre-feet (MAF) of water. It is a concrete gravity dam, designed to withstand the flow of the Satpara River and regulate water flow for downstream usage. The dam's hydroelectric power station has a capacity of generating electricity, which is fed into the local grid network.

(4) Effects on Livestock and Agriculture

The Satpara Dam's irrigation water supply has transformed agriculture in Skardu valley, facilitating year-round farming and diversification of crops. This has led to improved socioeconomic stability, decreased poverty, and enhanced agricultural productivity in rural areas.

(5) Environmental and Social Considerations

While the Satpara Dam project has provided significant environmental benefits, concerns persist regarding habitat modification, alterations to river ecosystems, and potential negative impacts on biodiversity and water quality in the future. To mitigate adverse effects on affected populations, the project mandates the relocation of specific villages, demanding meticulous planning and implementation of compensation and rehabilitation measures.

4. Different On-going Projects of Pakistan

(1) Diamer-Bhasha Dam

This is one of the largest water projects in Pakistan aimed at providing water storage and hydroelectric power generation. The project was under construction. It intended to address water scarcity, generate electricity, and support economic development in the region."

(2) Dasu Hydropower Project

Located on the Indus River in Kohistan District of Khyber Pakhtunkhwa, Dasu Hydropower Project is another significant project contributing to power generation and water management in Pakistan. It aimed at harnessing the energy potential of the Indus River to generate electricity.

(3) Nai Gaj Dam

Work on Nai Gaj Dam (live storage capacity 0.160 MAF, CCA 28,800 Acres and generation capacity (4.2 MW) re-commenced and the contractor mobilized at site w.e.f October, 2021. It is designed to mitigate water shortages, enhance agricultural productivity, and support local communities in the region.

(4) Keyal Khwar HPP

Keyal Khwar HPP (generation capacity 128 MW) pre-qualification for Civil and E&M works is under process. Building Documents of civil works are under review by the donor KfW. Project to harness the power of the Keyal Khwar River to generate electricity and contribute to the country's energy sustainability."

5. MOHMAND DAM HYDROPOWER PROJECT (ON-GOING), PAKISTAN

The Pakistan Mohmand Dam Hydropower Project is a significant initiative undertaken by the Pakistani government to address the country's energy needs, particularly in the realm of hydropower generation. Here's a detailed overview of the project:

(1) Background

Pakistan has been grappling with a severe energy crisis for years, characterized by chronic power shortages, load shedding, and dependency on expensive fossil fuel-based energy sources.

In response to this energy deficit, the Pakistani government has been emphasizing the development of renewable energy sources, including hydropower, to enhance energy security and sustainability.

(2) Location

The Mohmand Dam is situated on the Swat River in the Mohmand District of Khyber Pakhtunkhwa province in

north-western Pakistan.The dam site is approximately 37 km upstream of the existing Munda Head works and around 5 km upstream of Munda village.

(3) Project Details

The Mohmand Dam Hydropower Project, commenced in 2019, aims to fulfil multiple objectives such as electricity generation, water storage, flood control, and irrigation. With significant progress made in construction, it is slated for completion in 2024, bolstering Pakistan's energy and water security. It centred on harnessing the Swat River's potential, the project includes a dam approximately 213 meters high, boasting a storage capacity exceeding 1.2 million acre-feet. With an estimated 800 megawatts of hydropower capacity, it will diversify Pakistan's energy mix, reduce reliance on thermal plants, and aid in water resource management through irrigation and flood mitigation downstream.

(4) Construction and Financing

- The project is being executed by the Water and Power Development Authority (WAPDA) of Pakistan, which is responsible for planning, designing, and implementing water and hydropower projects in the country.
- The construction of the Mohmand Dam Hydropower Project involves significant engineering challenges, including the relocation of affected populations, geological considerations, and environmental impact assessments.
- The financing of the project involves a combination of domestic and international sources, with support from the Pakistani government, multilateral development banks, and international donors.

(5) Benefits and Impacts

The completion of the Mohmand Dam Hydropower Project is anticipated to yield several advantages for Pakistan, such as

- Addressing the rising electricity demand, particularly during peak periods, thereby reducing power outages and enhancing the dependability of the power grid.
- It will also bolster water security by managing the flow of the Swat River, crucial for irrigation in downstream agricultural regions.
- Additionally, the project is poised to catalyse economic growth through the creation of jobs, investment opportunities, and improved industrial productivity fuelled by reliable and affordable electricity.
- Furthermore, it aims to mitigate the risk of floods by regulating water flow during monsoon seasons, thus safeguarding lives, property, and infrastructure.

In conclusion, the Pakistan Mohmand Dam Hydropower Project represents a critical endeavour to address the country's energy and water challenges through sustainable and renewable means. Despite the complexities and challenges associated with its implementation, the project holds immense promise in terms of delivering tangible benefits to Pakistan's economy, society, and environment, while also contributing to regional development and stability.

Indus Water Treaty:

The Indus Water Treaty, signed in 1960 between India and Pakistan, allocates the waters of the Indus River system between the two countries. The treaty grants control over the three eastern rivers, namely the Ravi, Beas, and Sutlej, to India, while Pakistan receives rights to the three western rivers, including the Indus, Jhelum, and Chenab. Despite its provisions for water sharing, disputes and tensions have arisen periodically between the two nations, particularly regarding the construction of dams and diversion projects on shared rivers. These disagreements stem from concerns over water security, agricultural needs, and hydropower generation, with both countries accusing each other of violating the treaty's terms. Efforts to address these issues have been on-going through diplomatic channels and occasional third-party mediation, yet the Indus Water Treaty remains a focal point in Indo-Pakistani relations, reflecting the complex dynamics of water management in the region.

Major Water Issues in Pakistan:

Despite significant water resources, Pakistan grapples with numerous challenges, exacerbating its water crisis.

(i) Water Security Issues in Pakistan

Water security poses a significant challenge to Pakistan's development, especially with its population projected to reach 263 million by 2050. The country must find sustainable solutions to meet the needs of agriculture, industry, and human consumption as its water reserves decline.

- Pakistan formerly utilized reservoirs, canals, and inter-basin transfers to support agriculture, which consumes 93% of its water. Mismanagement could now imperil this vital sector."
- Despite significant investments, Pakistan's irrigation systems in the Indus basin have shown inefficiencies, resulting in low crop yields per unit of water.
- Recognizing that challenges often stem from issues of scale, such as monitoring infrastructure and sharing expertise across institutions, there's a growing push towards smart water management powered by ICT.
- This approach involves knowledge and virtual water transfers to optimize resource allocation and ensure technological innovations meet the diverse needs of food security.

(ii) Economic Challenges:

- Raising livestock is the main source of livelihood of rural areas
- Due to less production of main crops the Industries related to them will suffer adversely.
- Then due to drought and more dependency on ground water for irrigation, the water table will go down, and this will because water constrains to the population.
- Less agricultural outputs will compel people to head towards urban areas for jobs.
- The distribution of water is controlled from the centre by IRSA (Indus river system authority) between the provinces. Now the shortage of water will cause disputes between the provinces.

(iii) Water Scarcity:

- Uneven Distribution: Water availability varies across regions, with Punjab and Sindh receiving more water

compared to Balochistan and Khyber Pakhtunkhwa (KP).

- Population Growth: Rapid population growth strains water resources, increasing demand and exacerbating scarcity.
- Climate Change: Erratic weather patterns, including prolonged droughts and floods, further exacerbate water scarcity issues.

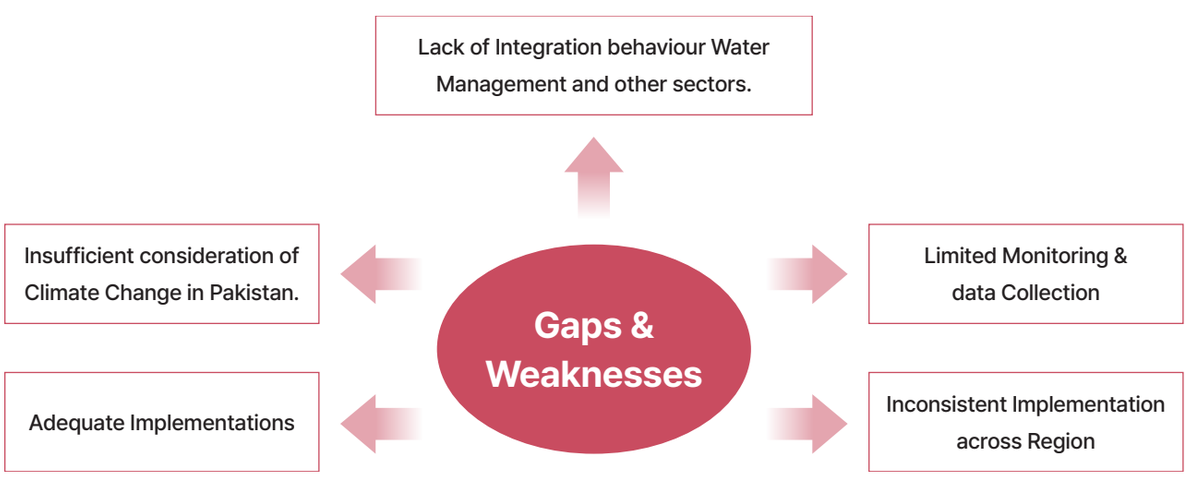
(iv) Water Contamination:

- Industrial and Agricultural Pollution: Discharge of untreated industrial effluents and agricultural runoff containing pesticides and fertilizers pollute water bodies, leading to health hazards.
- Urbanization: Inadequate sanitation infrastructure in urban areas results in the contamination of water sources with sewage and other pollutants.

(v) Inefficient Water Management:

- Out-dated Infrastructure: Aging irrigation infrastructure leads to water losses through seepage and evaporation.
- Inequitable Distribution: Unequal access to water resources and inefficient distribution mechanisms contribute to conflicts among provinces and within communities.

(vi) Summary & Weaknesses in the current Policies & Regulations of Water Resources Management:



6. Solutions to Pakistan's Water Crisis

Addressing Pakistan's water challenges requires a comprehensive approach involving policy reforms, infrastructure development, and community engagement.

(1) Policy Reforms

- Integrated Water Resource Management: Implementing a holistic approach to water management, considering environmental, social, and economic factors.
- Legislation and Regulation: Enforcing stricter regulations on water usage, pollution control, and groundwater extraction to ensure sustainable practices.
- WAPDA Capacity: Be further enhanced.

(2) Infrastructure Development

- Modernizing Irrigation Systems: Upgrading irrigation infrastructure to minimize water losses and improve efficiency through techniques such as drip irrigation and laser land levelling.
- Investment in Water Storage: Building dams and reservoirs for water storage to mitigate flood risks, regulate river flows, and provide water during dry spells.

(3) Conservation and Awareness

- Promoting Water Conservation: Educating farmers and the public about water-saving practices, such as crop rotation, mulching and rainwater harvesting.
- Public Awareness Campaigns: Raising awareness about the importance of water conservation and pollution prevention through media, schools and community programs.

(4) Construction of Kalabagh Dam

There is a need to evolve consensus over the construction of Kalabagh Dam which has been pending for six decades. Undue and unreasonable criticism against the Kalabagh Dam, particularly by Sindh and KP further aggravates the issue of water scarcity in Pakistan. From any standpoint; Kalabagh Dam is still the most feasible water project in Pakistan which can ensure irrigation water amounting to millions of acre feet as well as 6,000 megawatts of electricity.

(5) International Cooperation

- Indus Water Treaty: Strengthening cooperation with India under the Indus Water Treaty to ensure equitable sharing of river waters and mitigate Tran's boundary water disputes.
- Regional Collaboration: Collaborating with neighbouring countries on water management projects and sharing best practices for sustainable water use.

Conclusion

Pakistan's water crisis is a complex issue demanding immediate attention and collaborative efforts from governmental, societal, and international stakeholders. By embracing comprehensive water management strategies, investing in infrastructure, advocating conservation, and fostering collaboration, Pakistan can address its water challenges and ensure water security for present and future generations. The country faces numerous severe problems in its water sector, and it's known that there's potential to generate approximately 83 million acre-feet (MAF) more water. Hence, constructing more reservoirs and implementing effective management

strategies are imperative. Executing these recommendations will enable Pakistan to confront challenges and achieve the objectives of sustainable development and management of its limited water resources. Additionally, it will allow for the optimization of water usage for a prosperous future. Despite being among the world's poorest nations, Pakistan has a rapidly growing population, surpassing 140 million, with a concerning growth rate of approximately 3% that needs to be addressed. Concurrently, agricultural growth is declining due to water scarcity, necessitating the cultivation of additional lands to match population growth. Meeting agricultural growth targets requires substantial water resources, projected to increase from 277 MAF by 2025. This trajectory indicates Pakistan's transition from a water-abundant to a water-scarce nation. This water shortage jeopardizes the country's federal structure. Failure to treat water as an economic asset and insufficient acknowledgment of associated environmental concerns has exacerbated this critical situation. Urgent action is required to avoid potential water riots and social or political upheaval. Given the absence of additional water resources, it's imperative to acknowledge responsibilities and take corrective measures promptly. Water security be given a national priority.

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Asian Water through Country

Middle East

Saudi Arabia

Ministry of Environment, Water and Agriculture
(MEWA)

1. Introduction

(1) Saudi Arabia Water Sector Characteristics

Despite being in a region with extreme water scarcity, Saudi Arabia boasts a resilient water sector that, since 2016, doubled water production for urban use to reach 16.5 million cubic meters per day, doubled its strategic water storage to 26 million cubic meters, and the water conveyance pipeline network capacity is 16.5 million cubic meters pers day. This comes as a direct result of the launch of the National Water Strategy 2030 with its ten programs covering water legislation and policies, emergency plans, restructuring of the sector stakeholders with clear intra-linkages and roles, with key performance indicators that are monitored and reported to policy makers. Policies that harmoniously intertwine with NWS 2030 led to reducing the production of non-renewable groundwater to the half most of it a result of policies regulating the cultivation of fodder.

Natural water resources in the Kingdom are scarce and mostly non-renewable. To this effect, instruments to manage water demand to save the natural resources while sustaining water supply for urban, agriculture, and industrial use to support the fast-growing socio economy becomes a primary target. A bundle of Instrument puts the Kingdom on track for Demand Management of non-renewable groundwater resources while providing water for sustainable socio-economic growth.

Instruments of Water Demand Management for Water Resources:

Water Resources in Saudi Arabia:

(1) Groundwater

The Kingdom has a reserve of non-renewable groundwater across a group of aquifers with groundwater collected in more than 20 primary and secondary aquifers across the country serving several regions. All primary aquifers are located in the Arabian Shelf. In contrast, the Arabian Shield does not include any primary or secondary aquifers due to its non-porous, rocky nature.

In addition, renewable groundwater is found in shallow and deep aquifers as well as surface water of valleys. Based on estimates, renewable groundwater is currently estimated at 2.8 billion m^3 per year in the Arabian Shield region.

(2) Surface Water

The total reserve of exploitable water from dams amounts to ~1.6 billion m^3 per year, with the majority of the total exploitable water from dams being in the regions of Aseer, Makkah, and Jazan, which also include an abundance of renewable groundwater and surface water due to their rocky, non-porous terrain across the Arabian Shield.

(3) Desalinated Sea Water

There are more than 37 seawater desalination plants on the eastern and western coasts of the Kingdom with a total production capacity for seawater desalination reaching ~9 million m^3 per day in 2023. This positions Saudi Arabia as the world's largest producer of desalinated water.

(4) Treated Urban and Industrial Wastewater

Treated wastewater is produced upon the treatment of sewage to a degree that makes it safe to use for various

purposes including industrial processes, cooling, mining, and agriculture. In the last year (2023), the percentage of treated wastewater reused across the Kingdom reached about 23% of total treated wastewater.

To ensure water supply for socio economic development while managing demand, The Saudi Council of Ministers endorsed the NWS 2030 in 2018, embarking on an ambitious ten programs fulfill the aspirations of reducing demand on non renewable groundwater resources. The NWS 2030 a well-structured framework that took into consideration the water sector's current state assessment. This includes relevant previous studies, as well as the identified sector's challenges, opportunities, priorities, and stakeholders' future vision.
The NWS 2030 has set a vision to establish a sustainable water sector that safeguards natural resources and the environment while providing cost-effective supply and high-quality services contributing to socio-economic development. The vision is strengthened and further delineated by five key strategic objectives:

- Ensure continuous access to adequate quantities of safe water under normal operations and during emergency situations.
- Enhance water demand management across all uses.
- Deliver cost-effective and high-quality water and wastewater services, accounting for affordability.
- Safeguard and optimize the use of water resources while preserving the local environment for the highest benefit of Saudi society in this generation and the future.
- Ensure water sector competitiveness and positive contribution to the national economy through promoting effective governance, private sector participation, localization of capabilities, and innovation.

A set of instruments enabled fast achievements of targets. These instruments include:
1 Increase the production capacity of desalinated sea water to safeguard the non-renewable water resources
2 Complete a detailed supply and demand analyses and framework for urban water supply and reuse up to the year 2050
2 increase the reuse of treated sewage effluent for both agriculture, industrial, and construction use
3 Enact a series of policy instruments in the form of laws and regulations that ensure improved services and reduction of non-renewable groundwater resources
4 launch a country wide remote groundwater abstraction metering initiative to rationalise water use for irrigation
5 launch a country wide remote monitoring initiative for tracking of well drilling activities through devices linked with the well licensing system
6 Establish a central data hub for all water sector data linkages and data reporting protocols as well as artificial intelligence based decision support system
7 Expand of a national water resources monitoring network for groundwater, surface water, and rain across the entire Kingdom
8 Approve and plan to build additional 1000 dams in addition to the existing 570 dams to harvest, recharge, and mitigate risk of surface water
9 Establish the National Centre for Water Efficacy and Rationing
10 Conduct a water resource valuation project to form a foundation for a tariff system and a tool for water resource allocation
11 Promote privatization and financial efficiency through the Saudi Water Partnership Company
12 Improve the Environmental aspects of water production through cost recovery through mining sea water ad reduce the carbon footprint through use sustainable energy

2. Selected Completed Projects

(1) National Water Valuation Study

a. Description

The Ministry of Environment, Water, and Agriculture (MEWA) is currently conducting the National Water Valuation Study, a comprehensive initiative aimed at determining the total economic value of water at a national level across all water resources and the different usages in Saudi Arabia. The total economic value of Water acknowledges the multifaceted nature of water resources considering not only their direct economic contributions but also their broader environmental and social benefits. The study aims to equip policymakers and stakeholders with a comprehensive understanding of the significance of water resources guiding informed decision-making to promote sustainable water resource management in the face of mounting pressure on water reserves in the country.

b. Challenges

The challenges of Saudi Arabia's arid climate, rapid population growth, and economic development, along with keen plans to significantly reduce demand on non-renewable groundwater to relief further strain on the country's water resources, highlight the pressing need to assess the total economic value of water resources comprehensively.

c. Solutions

The outcomes of the National Water Valuation Study aim to inform decision-making processes across sustainable water resource management and water demand management policies. Regarding sustainable water resource management, the total economic value of water provides insights into the true worth of water resources, facilitating measures to safeguard water quality, protect ecosystems, and promote resilience in water supply. The total economic value of Water also helps with water demand management by ensuring that water resources are efficiently distributed across different sectors. This enables policymakers to prioritize water distribution based on societal needs, economic productivity, and environmental sustainability, thereby minimizing waste and effectively meeting competing demands.

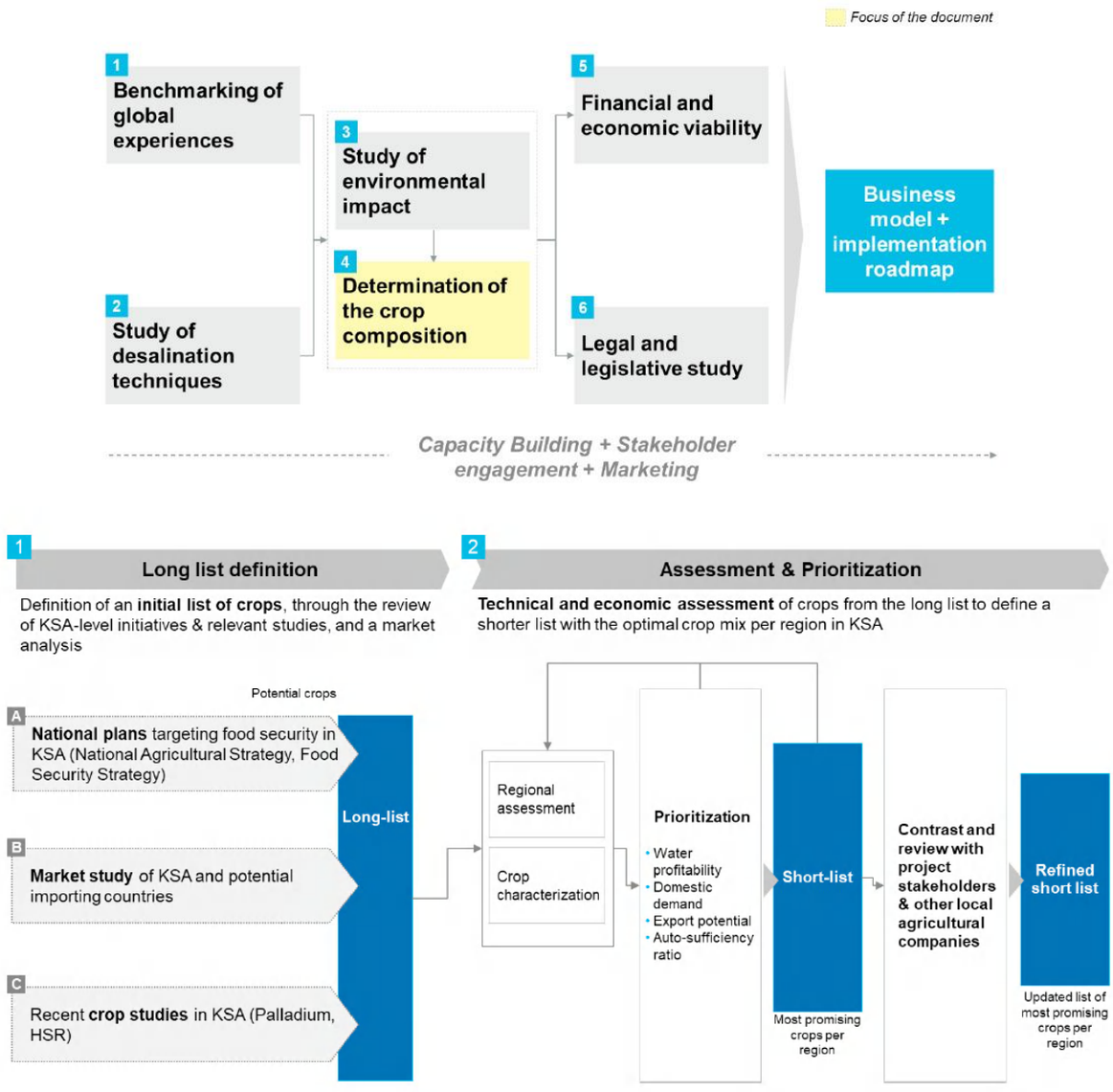
(2) Assessment of Desalinated Seawater Use in Agriculture Project

a. Description

To reduce the demand of non-renewable groundwater for agriculture, The Ministry of Environment, Agriculture and Water conducted a comprehensive assessment of desalinated seawater (DSW) usage in Saudi Arabia's agricultural sector by carrying out a technical, environmental, economic, and social feasibility studies. A six-phase approach has been designed and adopted to ensure the project's success, as illustrated in the following figure.

b. Challenges

Various approaches have been employed to assess the feasibility of each phase. For example, a two-step approach has been followed to determine the most economically feasible crop composition to use



desalinated seawater (DSW) in the Kingdom. First, an initial long list of potential crops was defined based on a comprehensive review of national-level initiatives, market analysis, and relevant studies related to the current crop composition in the Kingdom. Subsequently, the long list of crops was assessed from a technical and economic perspective to identify the most feasible crops, as delineated in the figure below.

c. Solutions

The study findings indicate the feasibility of integrating desalinated seawater into agricultural practices in the Kingdom, with certain limitations and constraints to be taken into account. From a water cost perspective, some of the main drivers of supporting its viability are; high production capacities (>500,000 m^3/d) and short pumping distances (<50 km and <400m of height). From a cultivation perspective, high-cash greenhouse vegetables and cut flowers are preferred as their water profitability exceeds the cost of water in a significant number of production and transmission scenarios.

(3) Groundwater Management Project

a. Description

The Arabian Peninsula is characterized by two primary geological subdivisions: the Arabian Shelf and the Arabian Shield. Almost all of Saudi Arabia's groundwater is found in several large sedimentary basins with thick, highly porous aquifers within the Arabian Shelf. Groundwater is primarily sourced from two different aquifers: shallow alluvial aquifers and deep rock aquifers. The deep rock aquifers are sedimentary in origin, often composed of sandstone and limestone and cover thousands of square kilometres. They have a limited natural recharge in upland and foothill regions where the rocks have outcrops on the surface.

b. Challenges

Groundwater serves as a vital resource for fostering sustainable economic development in the region. However, the heavy reliance of agriculture on non-renewable groundwater demands mitigation of the mining of aquifers.

c. Solutions

As part of the National Water Strategy 2030 (NWS 2030), The Water Resources Management Program (Program 02) is designed to manage non-renewable groundwater resources (NRGW) effectively. Specifically, Initiative 4 aims to execute the practice of integrated water resources management (IWRM) in addition to Initiative 11 which focuses on the development of NRGW and assesses the value of NRGW at the water resources management unit level.

Accordingly, and in line with the NWS 2030 initiatives, The Ministry of Environment, Water, and Agriculture (MEWA) has recently launched the Groundwater Modelling Project (GWMP) which aims to conduct a comprehensive review of existing data and regional groundwater models to enhance understanding and facilitate effective water resource management.

The first phase of the GWMP involves a thorough evaluation of current regional groundwater models considering elements such as model framework, input data, calibration, and validation. The project will identify aquifers and hydrogeological elements important for local groundwater models. It will also evaluate the appropriateness of regional models for managing water in water management areas. The collection and evaluation of existing data encompassing groundwater, geological, hydrogeological, and surface water data, will be conducted to ensure its quality and consistency. The analysis will also identify any deficiencies or constraints in the data such as the absence of data points, space or time gaps, and format inconsistencies.

Upon the completion of the initial phase of the GWMP, improved mathematical models will be developed to provide water resource managers with practical tools for understanding various hydrological processes. The IWRM framework will facilitate the identification of effective management strategies for groundwater resources through stakeholder collaboration and data-driven decision-making. This will enable the sustainable allocation and conservation of water resources across the Kingdom.

3. Detail of the "National Water Valuation Study"

(1) Nation Water Valuation Study

a. Description

The Ministry of Environment, Water, and Agriculture (MEWA) is currently conducting the National Water Valuation Study, a comprehensive initiative aimed at determining the total economic value (TEV) of water at a national level across all water resources (i.e., desalinated water, groundwater, surface water, and treated wastewater) and the different usages in Saudi Arabia.

The total economic value of water acknowledges the multifaceted nature of water resources, considering not only their direct economic contributions but also their broader environmental and social benefits. By encompassing all economic, environmental, and social dimensions, the study aims to provide a holistic understanding of the value of water resources in Saudi Arabia, which is crucial for informed decision-making and sustainable water resource management practices.

To determine the total economic value of each water resource, a rigorous methodology is applied that involves evaluating both use values and non-use values associated with water. Use values encompass the tangible benefits derived from the actual utilization of water such as irrigation, industrial processes, and domestic consumption. While non-use values represent the intangible benefits derived from the mere existence or preservation of water resources.

Accordingly, the total economic value of water for each water resource is then calculated utilizing various valuation methods, including market-based approaches, revealed preference methods, and stated preference methods to quantify the different use and non-use values of water. The study aims to support policymakers and stakeholders by providing a better understanding of the importance of water resources and guiding policymaking to support sustainable water resource management amidst the significant strain on water resources in the country.

b. Challenges

The challenges posed by Saudi Arabia's arid climate, rapid population growth, and economic development, combined with keen plans to reduce reliance on non-renewable groundwater, underscore the urgency of comprehensively assessing the total economic value of water resources. Firstly, the arid climate, characterized by minimal rainfall and high temperatures, limits natural freshwater availability, necessitating careful management to meet increasing water demands.

Moreover, the Kingdom's plans to reduce reliance on non-renewable groundwater demands further innovative efforts. Arriving at sustainable abstraction rates of non-renewable groundwater is key to sustainable economy

As such, the total economic Value of Water framework serves as a vital decision-making tool for navigating the complex challenges posed by water scarcity in Saudi Arabia.

c. Solutions

The outcomes of the National Water Valuation Study mainly aim to facilitate informed decision-making for sustainable water resource management and water demand management policies.

- **Sustainable water resource management:** The total economic value of water provides insights into the true worth of water resources and the costs associated with their depletion or degradation. This supports the implementation of measures to safeguard water quality, protect ecosystems, and promote water reuse initiatives, as well as fostering the resilience and reliability of the water supply.
- **Water demand management:** The total economic value of water supports efficient allocation of water resources across the different water usages (i.e., agricultural, urban, industrial, and environmental users). Policymakers can prioritize allocations based on societal needs, economic productivity, and environmental sustainability. Additionally, it enables informed and prioritized investment decisions based on the benefits associated with water-related activities. This ensures that water resources are utilized optimally, minimizing wastage and addressing competing demands effectively.

4. Future Plan

At present, plans align with the National Water Strategy (NWS 2030). In the strategy, the Kingdom has initiated 10 key programs. The programs, spanning from legal and regulatory frameworks to infrastructure restructuring and capacity building, represent a holistic approach to water management and resilience:

1. **Water Law and Resource Management Regulations:** The program aims to establish comprehensive policies and regulatory frameworks for effective water resource management.
2. **Water Resource Management:** Based on integrated water resource management principles, the program optimizes the use of available water resources by rationalizing renewable and non-renewable groundwater, surface water, and treated wastewater.
3. **Sector Resilience:** The program assesses and addresses potential risks across the water supply chain, ensuring continuous water and wastewater sector operations in the face of disruptions.
4. **Innovation and Capability Building:** The program enhances leadership and water management capabilities, focused on research, development, and capacity building.
5. **Supply Chain Efficiency and Service Quality:** The program addresses operational and service quality challenges throughout the water supply value chain.
6. **Water Services Regulations:** The program ensures effective regulation of water services.
7. **Saline Water Conversion Corporation Restructuring:** The program involves the restructuring and transformation of Saline Water Conversion Corporation, part of the privatization strategy.
8. **Privatization in Production and Wastewater Treatment:** The program combines production assets and wastewater treatment assets for privatization purposes.
9. **Distribution Restructuring and Privatization:** The program prepares distribution utilities for privatization, transforming the distribution sector structure.
10. **Saudi Irrigation Organization Restructuring and Irrigation Improvement:** The program aims to restructure and empower the Saudi Irrigation Organization (SIO) to fulfil its role of improving irrigation practices and optimizing the treated water usage in the agriculture sector.

Currently, all of these programs are underway, embarking on a transformative journey to tackle challenges within the water sector. Significant budget on place to implement the strategy and to develop water resources and water services projects in an integrated system across the Kingdom.

5. References

KSA National Water Strategy 2030

KSA National Water Valuation Study