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Evolving water resources management in response to socio-economical changes: Japanese experience in modernization over the past century

Mikio Ishiwatari [a,b,*], K. Nagata[b] and M. Matsubayashi[b]

[a] The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa-shi, Chiba-ken 2778561, Japan
[b] Japan International Cooperation Agency, 5-25 Nibancho Chiyodaku Tokyo 1028012, Japan
*Corresponding author. E-mail: ishiwatari.mikio@jica.go.jp

MI, 0000-0002-5606-5036

ABSTRACT

As society develops, water resources management (WRM) should evolve in response to the changing public needs. This study examines the evolution of Japanese management mechanisms since modernization. Semi-structured interviews were conducted with decision makers and researchers, and government documents and academic papers were reviewed. We found that the country has developed legislation, financing investments, long-term plans, governance, and science and technology for WRM, and that the water sector contributed to modernization, reconstruction after World War II, and economic development. Japan has become more resilient to natural and biological disasters, more inclusive in providing equitable water services, and more sustainable in protecting the environment. However, issues of inflexible approaches, weak governance, and necessity of applying adaptation to climate and social changes were found.

Key words: environmental protection, flood protection, inclusiveness, integrated water resources management, resilience, water supply

HIGHLIGHTS

- This study examines the evolution of Japanese water resources management (WRM) mechanisms.
- These are useful lessons to resolve various issues that developing countries are facing.
- WRM can make a society resilient, inclusive, and sustainable in Japan.
- Establishing legislation, institutions, planning, and financing is crucial.
- The mechanisms had limited flexibility in environmental protection and demand projections.

INTRODUCTION

Water resources management (WRM) requires an integrated and longer-term approach, and must evolve to meet the changing needs of a society (Cardwell *et al.* 2006; Pahl-Wostl 2007; Cosgrove & Loucks 2015). This study aimed to analyse how WRM can contribute to a country's growth by resolving water issues; toward this end, it examines the contributions of WRM to national growth in Japan since modernization began in the late 19th century.

Sustainable Development Goal 6.5 requires the implementation of integrated WRM (IWRM) at all levels, including transboundary river basins. The UN Environment monitors the progress of IWRM, and Japan is classified as one of seven countries with a 'very high' implementation status (UN Environment 2018). The UN Environment assesses four key components: (i) the enabling environment of policies, laws, plans, and arrangements; (ii) institutions and participation; (iii) management instruments for informed decision-making; and (iv) financing. While 80% of countries have laid the foundation for IWRM, 20% have started developing IWRM approaches.

WRM has played an important role in modernization of Japan since the late 19th century, reconstruction after World War II, and high economic growth from the 1950s. It has contributed to the country becoming a resilient, inclusive, and sustainable society. Japan created modern WRM systems by introducing Western technology built on traditional water use, developed throughout its nearly 2000-year history, during which it expanded paddy fields by developing irrigation and

flood protection facilities, and established customs of river water use and community-based systems of water management and flood protection.

Recent studies have examined transitions in WRM in Japan (Takahasi & Uitto 2004; Musiake & Koike 2009), as well as Australia, Bangladesh, Egypt, England, the Netherlands, and the US from the perspectives of technology, legislation, and institutions (Bellamy *et al.* 2002; Mostert 2006; Benson *et al.* 2015; Craig 2020; Luo *et al.* 2020). However, only a few studies have examined how these WRM transitions contribute to national growth.

While there is no one-fits-all model for WRM across countries with various issues and backgrounds (Biswas 2008; Shams & Muhammad 2021), the findings of the present study are useful for the establishment of WRM in developing countries facing a wide range of water issues (JICA 2022). WRM needs 'to balance competing water demands from across society and the economy, without compromising the sustainability of vital ecosystems' (UNEP 2021). Japan had experienced various issues of land subsidence, urbanization, flooding, water shortage, water pollution, and ecosystem degradation. Other countries can understand what worked and did not work in Japan.

MATERIALS AND METHODS

Government documents and statistics were analysed to examine the transition of WRM and its impact on national growth. Semi-structured interviews were conducted with 10 decision makers in Ministry of Land, Infrastructure, Tourism and Transport (MLIT), Japan Water Agency, and a water users association and five researchers from April 2020 to March 2021. The interviews covered issues resolved, approaches taken, remaining issues, lessons from their experience. Feedback on the findings was received from 16 experts in MLIT, Japan International Cooperation Agency, multilateral development banks, and UN organizations.

RESULTS AND DISCUSSION

For nearly 2,000 years, Japan has established water allocation customs, the community-based organizations of managing water and floods, and traditional technology for water management to use river water for the irrigation of paddy fields and protect local communities from flooding. Based on WRM history, the modernized state started evolving legislation, financing investments, long-term plans, governance, and science and technology to manage water resources at the end of the 19th century and has succeeded in resolving emerging water issues (Figure 1).

UNEP (2021) reviews the progress of SGG 6.5 'to implement integrated WRM' and identifies the issues of coordination, financing, capacity, information, legal frameworks, and awareness. Japanese experience could show the approaches of resolving these issues that many countries are currently facing. This section examines the processes and outcomes in the following four stages and discusses issues at each stage.

Modernization (1870s to 1945)

Japan began its efforts to become resilient to flood disasters and infectious diseases, which became more severe during modernization, following the Meiji Revolution in the late 19th century. In 1898, Japan enacted the River Law to mitigate flood damage. This law enabled the national government to implement flood protection projects and increase the budget for flood protection. Furthermore, the government formulated long-term plans and a special account to secure a multiyear commitment and avoid annual fluctuations in budgets (Ishiwatari & Sasaki 2021). The government began constructing water supply systems to manage epidemics. Infectious diseases, for which death tolls reached over 100,000 in 1879 and 1886, substantially decreased because of improved public health with the development of water supply systems (JICA 2017, Figure 2).

Post-war reconstruction (1945–1950s)

Following the end of World War II in 1945, the government developed water resources, which are precious in the resource-scarce country, for electricity generation and food production to reconstruct devastated land. Hydropower generation accounted for 80% of total electricity generation in the 1950s, and remained the main electricity source until the 1960s. Total rice production increased from six million tons in 1945 to 14 million tons in the 1970s.

The government invested approximately 1% of the national income in flood protection infrastructure to mitigate the increased damage during and after the war. The country succeeded in reducing the death toll from over 1,000 approximately every year from 1946 until the 1950s to less than 300 in maximum after the 1980s, as well as economic damage from several percent of the gross domestic product in the 1940s to less than 0.5% after 1977 (Figure 3).

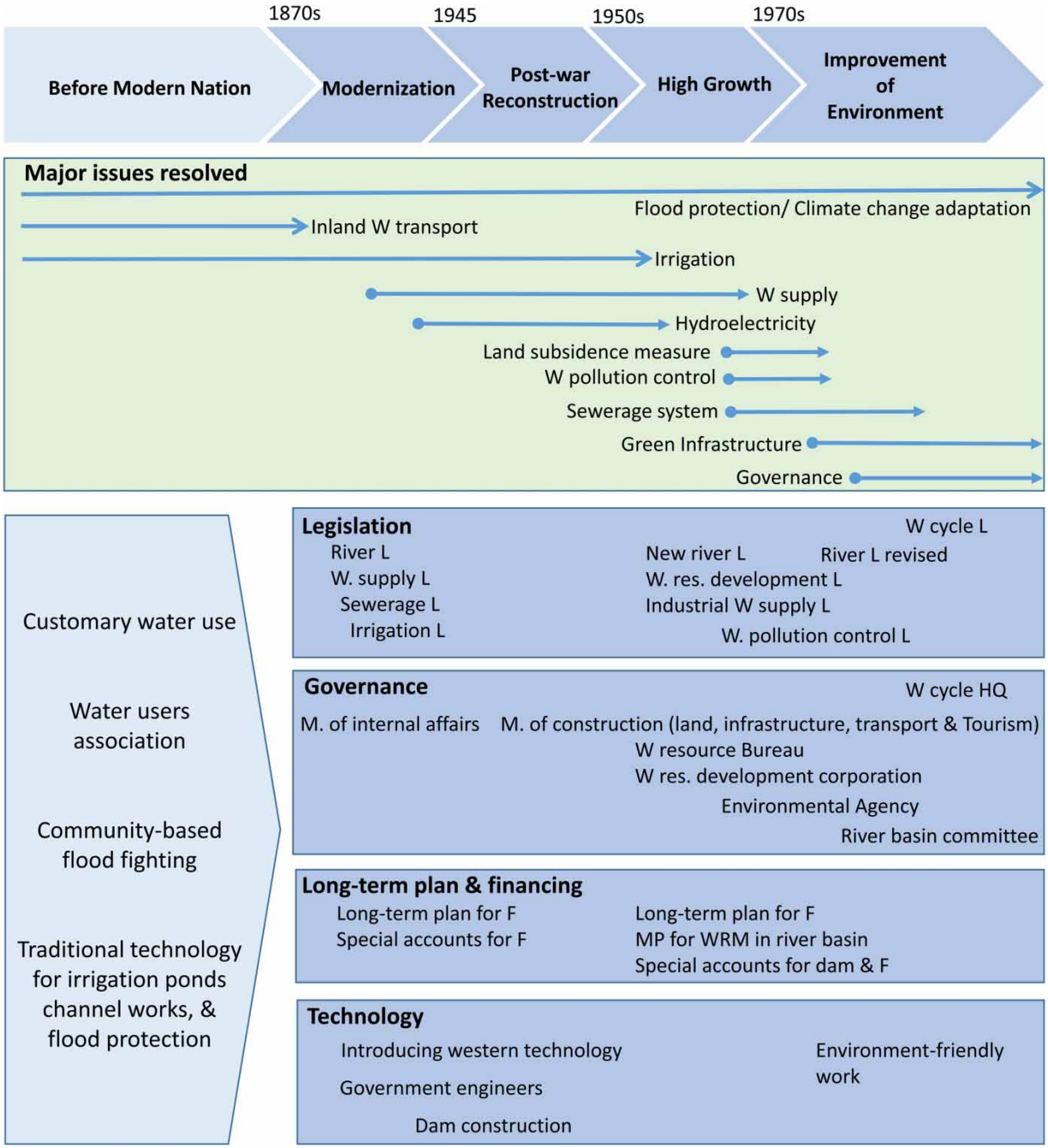

Figure 1 | Evolving mechanisms of water resources management in Japan. F: Flood protection; L: Law; M: Ministry; res: Resources; W: Water; HQ: Headquarters; MP: Master plan. *Source*: Authors' elaboration.

High growth (1950s–1970s)

Water resource development supported rapid economic growth and urbanization since the 1950s. With these efforts, the country could expand industrial production, and metropolitan areas could house residents who migrated from rural areas to seek job opportunities. Government organizations constructed infrastructure, such as dams, weirs, and water supply systems, to supply water to the industries and residents in metropolitan areas.

Japan developed legislation, institutions, and planning and financial mechanisms to respond to the increasing need for water resources. The government promoted WRM projects, particularly multipurpose dams, to reduce flood damage and

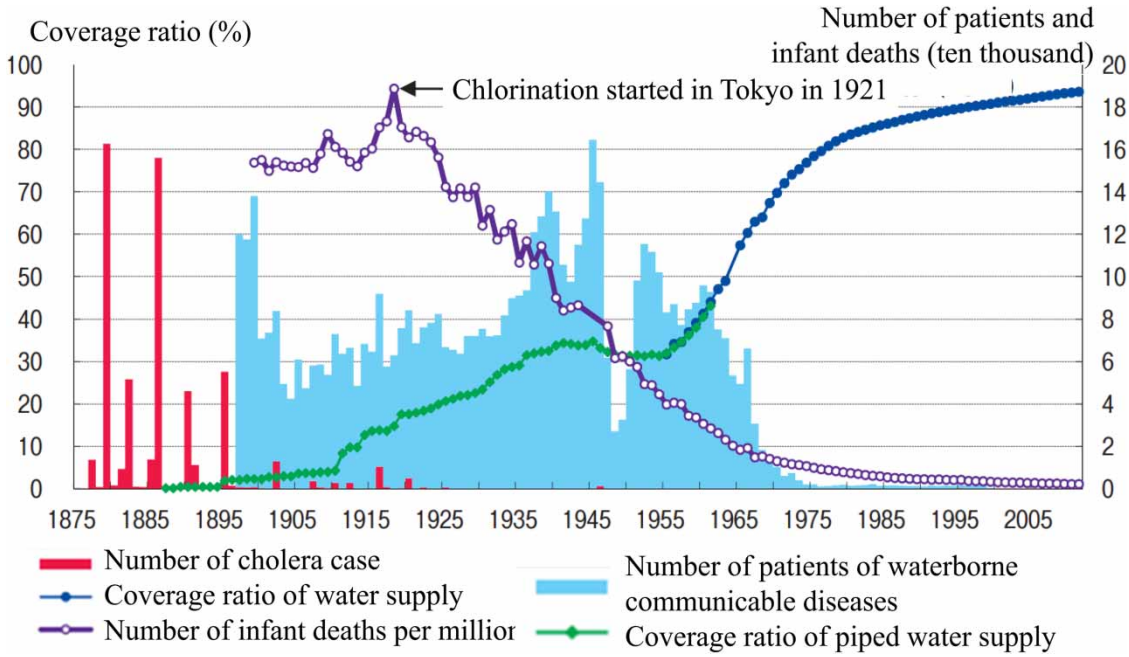

Figure 2 | Number of patients with waterborne communicable diseases and infant death and water supply. *Source*: MLIT.

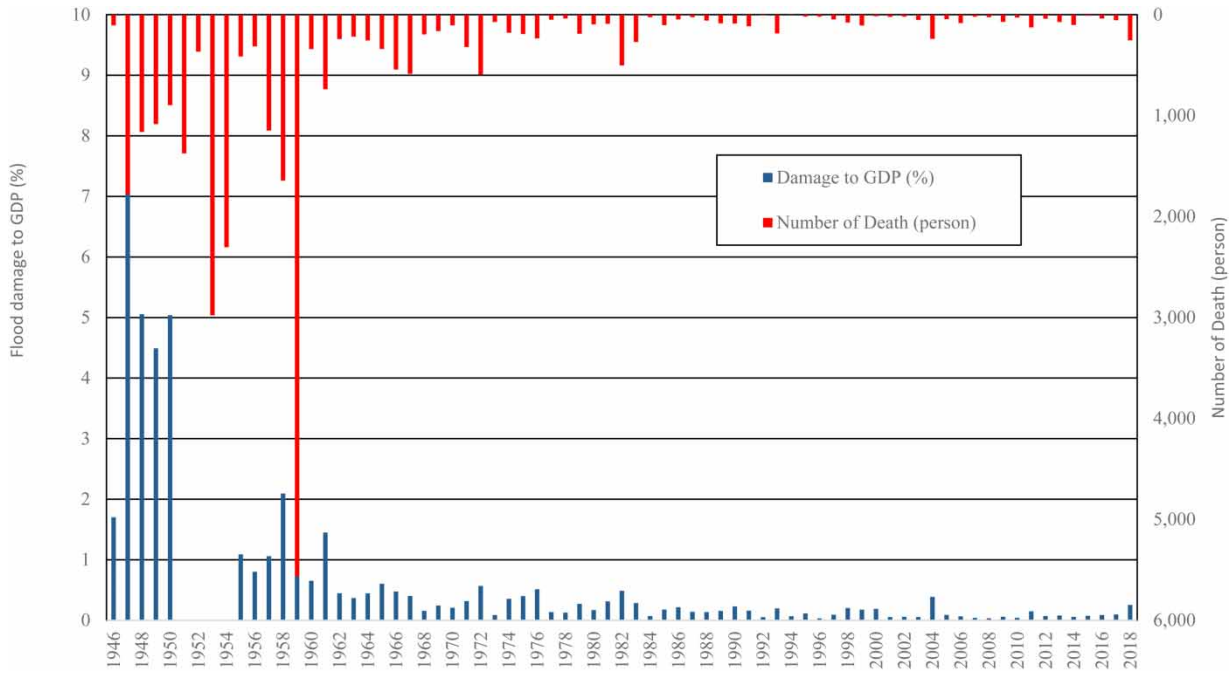

Figure 3 | Trends of flood damage. *Source:* GDP data, 'Changes in Japan's Post-war Finances and Future Challenges' 1946–1950, Ministry of Finance, 'Annual economic report,' long-term economic statistics from 1955 to 2019. Amount of flood damage and number of casualties: 'Statistical survey on flood damage' 2018 MLIT.

provide an urban water supply. The Multipurpose Dam Law and new River Law were enacted in 1957 and 1964, respectively, to develop water resources in an integrated manner. The legislation clarifies the responsibilities and costs shared among water users and the concerned organizations. As in other countries, several ministries administrate flood control, water supply,

irrigation, environmental measures, and hydropower generation. In addition, local governments manage water supply and sewerage entities, and local communities manage irrigation systems. The water resource department was established in 1961 by the government to coordinate policies among various organizations at the national level. Water Resource Development Public Corporation, a public agency specializing in implementing WRM projects, was established in 1961. The corporation coordinates various organizations concerned to promote multipurpose facilities. The government formulated master plans for WRM in major river basins to meet the increasing need for urban water supply in the face of urbanization and industrial development. A river basin is an appropriate unit for optimizing WRM (Takahasi 2009b). The government re-established the mechanisms of long-term plans and special accounts in the 1960s and secured a multiyear commitment for investments in WRM.

Local governments have developed industrial water supply systems to meet the needs of industrial production. The value of product shipments in 1985 was nine times that in 1965 (Figure 4). The industrial sector made efforts to recycle water, and the recycling ratio increased from approximately 30% in 1965 to over 60% in the 1970s. Therefore, the amount of industrial water has not increased since the 1970s. The industrial water supply system is unique in Japan and is used only for industrial purposes and not for drinking. Because sterilization is not required, the cost is lower than that of ordinary water supply systems.

WRM supported urbanization during the high growth. Between 400,000 and 650,000 people migrated annually from rural to metropolitan areas between 1956 and 1970 seeking job opportunities. The expanding capacity of the water supply enabled migration to urban areas. Tokyo's population doubled in 1981 from that in 1951, and the capacity of water supply increased 3.3 times after developing WRM facilities.

WRM contributed to inclusive growth together with labour and social security policies by supporting migration from rural to urban areas. The Gini coefficient in the country improved from 0.40 in the 1960s to 0.35 in the 1970s because of increasing incomes.

The quality of life was also improved because of water projects. For example, the urban poor in Hiroshima City, which was termed 'Atomic bomb slum' because people affected by World War II lived along rivers, were provided affordable public housing along with flood protection.

The government has provided access to water and sanitation for approximately all of them. The coverage ratio of water supply reached 90% in 1980 (Figure 2), and the ratio of sewerage increased from 10% in 1965 to 80% in 2019.

Japan has established an order of water use based on its past use and development history, customs, and circumstances. Government offices issue permits to water users based on the amount and purpose of water intake. Irrigation users who used water prior to the introduction of the modern legislation system in the 19th century were granted customary water rights. The total amount of customary water rights accounts for approximately 30% of total river water use as of today. Water users have established a drought coordinating committee to set rules for regulating water intake in the spirit of

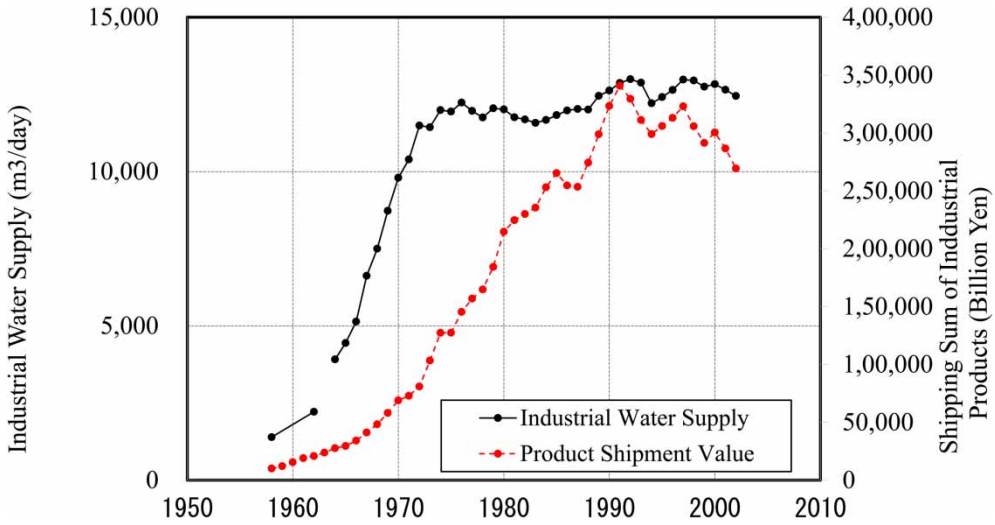

Figure 4 | Industrial water supply and industrial production. *Source*: Based on data from Industrial Statistics Data Library.

mutual concession. Because water users formulate their rules based on the history and circumstances of each river basin, the rules vary. Some rules prioritize the old rights of irrigation, but others prioritize drinking water supply.

Improvement of environment (1970s)

Development activities supported economic growth but hindered sustainability. These activities negatively affected people's health and environment in the 1950s. Pollution diseases caused by wastewater from industrial factories have killed over 1,500 people and affected the health of over 50,000 people in Minamata. The government delayed the establishment of effective regulations for industrial wastewater by considering the effects on economic activities. Regulation began in the 1970s when the problem had already become severe. This shows that regulations and ex-ante investments in environmental protection are essential for sustainable development.

Urbanization has worsened the flood damage in highly developed areas. The national government prioritized investment in flood protection in urban areas from the 1970s to mitigate urban flooding. Excessive groundwater use causes land subsidence, leading to building damage and more severe floods in urban areas. In the Tokyo downtown, lands subsided by some 4 meters. Local governments can suspend subsidence by regulating groundwater use and changing water sources to reservoirs and industrial water supply systems.

It has become difficult for government organizations to respond to the diversified needs of people as society matures. Local communities and civil society organizations have claimed that large-scale projects, such as dams and weirs, have become controversial political and social issues (Takahasi 2009a). The government developed legislation and financial mechanisms to mitigate social impact by supporting people affected by large-scale projects in the 1970s. Beneficiaries' downstream share the costs of rehabilitating the daily lives of affected people at relocation sites (Figure 5). Since the 1980s, civil society organizations have questioned the necessity and environmental impact of constructing large-scale facilities. Japan amended the

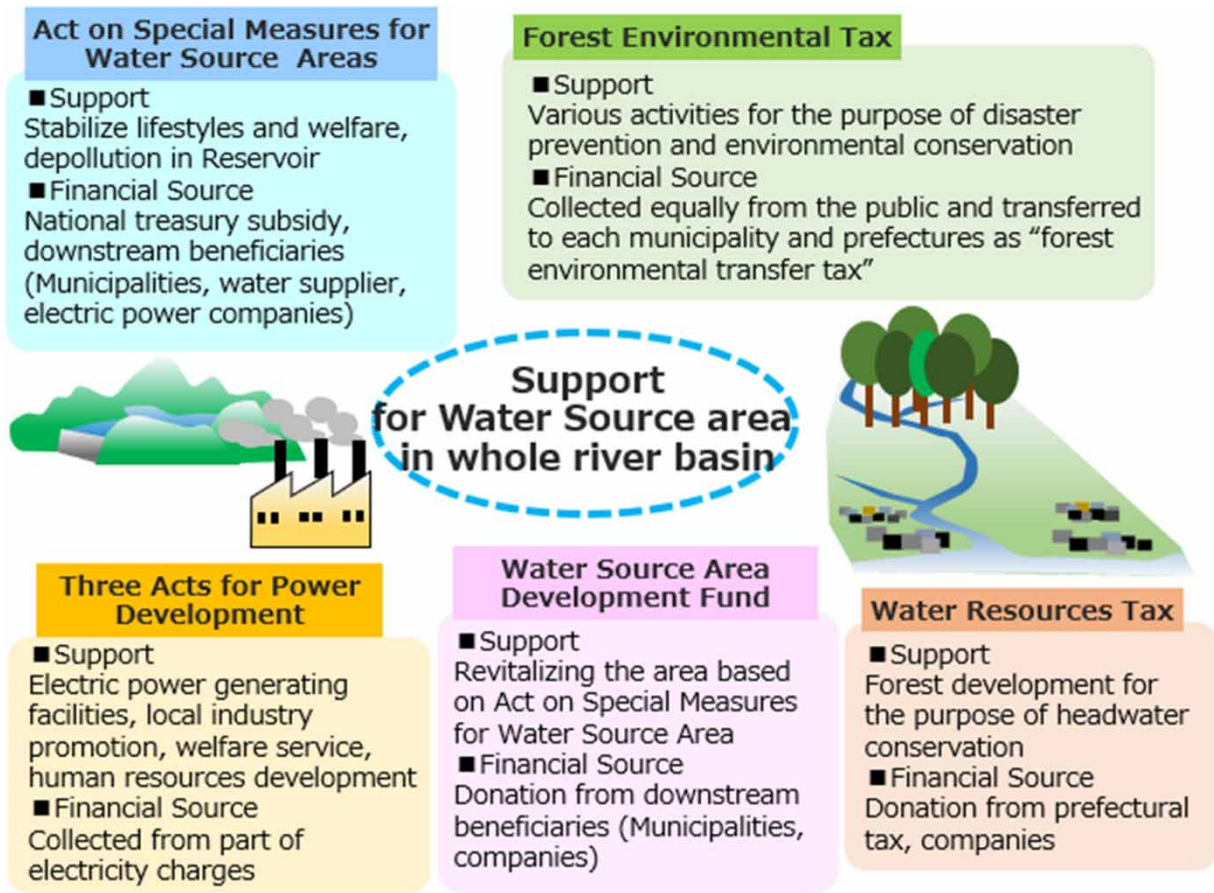

Figure 5 | Support for water source areas in the river basin. *Source*: JICA (2022).

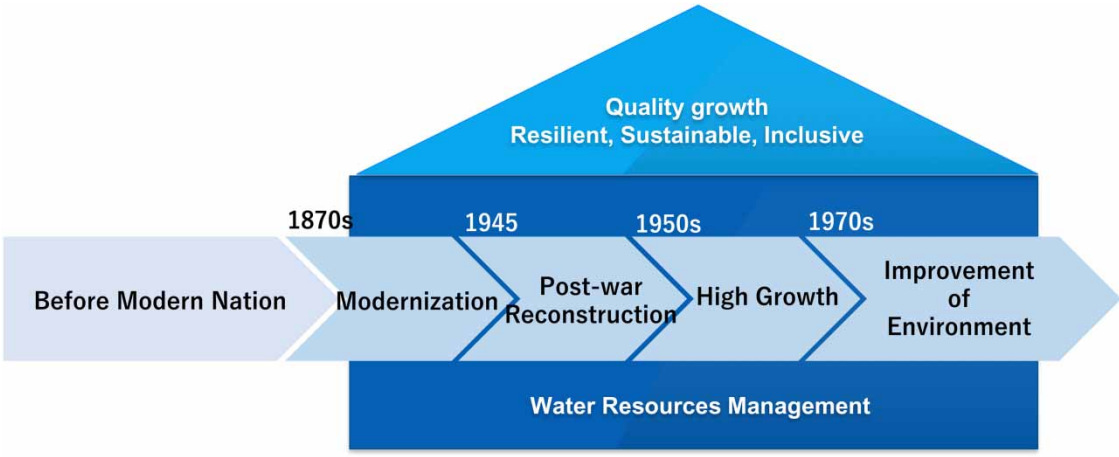

Figure 6 | Contribution by water resources management to quality growth in Japan.

River Law in 1997 to strengthen governance by establishing river basin committees in which local communities could participate in decision-making processes.

The government adopted a nature-oriented approach or green infrastructure in the 1980s, which used natural functions for flood protection (Nakamura 2022). This approach contributes to improving ecosystems, stimulating tourism, and providing leisure and study opportunities.

Issues

Some issues were found when reviewing the trends in Japanese WRM. Japanese mechanisms have limited flexibility, leading to delays in responding to pollution and revising demand forecasts. Until 1970, the government was unable to initiate regulations following the outbreak of polluting diseases in the 1950s.

The government could not promptly revise the demand projection of water resource development plans. Following high growth, water demand started decreasing in the 1990s, but the government continued to promote facility construction. While the procedures and mechanisms of constructing facilities are well developed, those of suspending construction had not been established.

MLIT started reviewing dam projects in 1995 and has so far cancelled 115 projects. Further, the ministry introduced a re-evaluation mechanism for all infrastructure projects in 1998 to determine whether a project should be improved or cancelled, if necessary. The government re-evaluates projects that have not yet begun construction 3–5 years after project adoption and ongoing projects five years after project adoption.

Governance has been strengthened by revising the river law, and involving stakeholders in the decision-making process remains a challenge. Various governance arrangements were developed for each river basin.

The country started promoting a new approach to adapt to the effects of the changing climate and society. This approach comprises multilayer measures in catchment and flood risk areas of the entire river basin, in addition to conventional structural measures. Coordinating a wide range of organizations is challenging (Ishiwatari 2022). Recently, floods have become more severe. The death toll of the 2018 floods reached over 200 people, the first time since 1982. The economic damage caused by Typhoon Hagibis in 2019 hit a record high of 1.9 trillion JPY.

CONCLUSIONS

This study examined the evolving process of Japanese WRM following the country's modernization in the 19th century. It was found that WRM can make a society resilient, inclusive, and sustainable (Figure 6). The country responded to changing needs in the water sector of society. WRM contributed to modernization in the 19th century and the first half of the 20th century, reconstruction after World War II, high growth since the 1950s, and environmental improvements. The country has managed water resources by resolving competing purposes and areas to support quality growth. Japanese experiences show that

establishing legislation, institutions, planning, financing, and other modalities is crucial for promoting WRM. These can be regarded as useful lessons to resolve various issues that developing countries are facing.

Japan prioritized economic development than environmental protection during high growth, which caused pollution diseases, such as Minamata disease, land subsidence, and urban flooding. The country was forced to invest countermeasures against them. Its mechanisms have limited flexibility in environmental protection and demand projections. These are also lessons from Japanese experience. Currently, the country is making efforts to resolve issues of governance and to adapt effects caused by climate change.

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DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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