Mitsubishi Research Institute, Inc.

ADBInstitute

PRINCIPLES OF INFRASTRUCTURE

Case Studies and Best Practices

Hideo Nakamura, Kotaro Nagasawa, Kazuaki Hiraishi,
Atsushi Hasegawa, KE Seetha Ram, Chul Ju Kim, and Kai Xu

ASIAN DEVELOPMENT BANK INSTITUTE

MITSUBISHI RESEARCH INSTITUTE, INC.

ADBInstitute

PRINCIPLES OF INFRASTRUCTURE

Case Studies and Best Practices

Hideo Nakamura, Kotaro Nagasawa, Kazuaki Hiraishi,
Atsushi Hasegawa, KE Seetha Ram, Chul Ju Kim, and Kai Xu

ISBN 978-4-89974-107-7 (Print)
ISBN 978-4-89974-108-4 (PDF)

This publication was jointly prepared by the Asian Development Bank Institute (ADBI) and the Mitsubishi Research Institute (MRI).

It was originally published in the Japanese language as インフラストラクチャー概論 by Nikkei Business Publications, Inc. (Nikkei BP) on 22 July 2017. ADBI and MRI acknowledge Nikkei BP and the authors for their kind permission to prepare an English edition and to freely use copyrighted material from the original book. The coherence of the translation with the original text is the responsibility of the editors and translation team.

Note: In this publication, "$" refers to US dollars.

Asian Development Bank Institute
Kasumigaseki Building 8F
3-2-5, Kasumigaseki, Chiyoda-ku
Tokyo 100-6008, Japan
www.adbi.org

Mitsubishi Research Institute, Inc.
10-3, Nagatacho 2-chome
Chiyoda-ku
Tokyo, 100-8141, Japan
www.mri.co.jp/english/index.htm

Contents

Tables, Figures, and Boxes

Tables

Figures

Boxes

Acknowledgments

It was 24 November 2017 when I was asked for help from K. E. Seetha Ram. He said he would like to translate his former teacher's book with the help of his young students in the Department of Civil Engineering at the University of Tokyo. He asked me to recruit the students, and he promised to proofread their translations. Although the book was written simply, its 400 pages cover a wide range of infrastructure topics from history to mathematical analysis. Although it seemed quite difficult to complete, amazingly, as many as 11 students raised their hands. With the help of the coauthors, their preliminary translation was finally completed in 9 months by the end of September 2018.

We would like to thank Naoto Yokozawa, in charge of Chapter 6, who was the first to complete a massive chapter in a month; also to Aoi Watanabe, who worked on parts of Chapter 2 while on a short stay in New Zealand; to Kotaro Hamada, in charge of the Preface and parts of Chapters 2 and 3, who took great care in his work and handled sections others were unable to complete; to Rika Idei, in charge of Chapter 7, who advised us using her professional experience and completed her parts while working on her doctoral thesis; to Pei Yuxiang, in charge of Chapter 1, who is Chinese but surmounted the challenge of the most cultural and historical chapter; to Yoko Ito, in charge of Chapter 4, who checked each sentence carefully with the coauthor, Atsushi Hasegawa; and to Ryo Ito, in charge of Chapter 3, who translated the most difficult parts full of Japanese technical terms. We are also grateful to Takeshi Miura, in charge of translating Chapter 5 and Ryuta Kuniyoshi, in charge of reviewing Chapter 2, who carefully reviewed the junior members' translations. Each student did their best under their various limited conditions. Their translation was carefully completed following a volunteer check from the three coauthors, Kotaro Nagasawa, Kazuaki Hiraishi, and Atsushi Hasegawa of their own chapters; Hisa Shibata in charge of the Preface, who is the wife of a former student of Professor Nakamura; and me in charge of Chapter 2. Finally, the full manuscript was checked by Lakshmi Seetha Ram and K. E. Seetha Ram.

We are grateful for guest contributions to the book from Asian Development Bank Institute Deputy Dean Chul Ju Kim and Kai Xu, a doctoral student at the University of Tokyo. We would also like to express our sincere appreciation to the Asian Development Bank Institute's outreach team, David Hendrickson, Adam Majoe, and Ainslie Smith for their overall guidance and support; our gratitude to Patricia Wada, who did an excellent job with the copyediting; and Principe Nicado, who completed the layout within a short period for launching during the T20 Summit.

It has been our dream to translate Professor Nakamura's book through the cooperation of his old students and new grand-students in the Department of Civil Engineering at the University of Tokyo and to deliver it to people in the world who need infrastructure development in their countries.

We would like to thank all those who have helped our dream come true.

Ayuko Akaike

List of Contributors

Hideo Nakamura is president emeritus of Tokyo City University, a professor emeritus of the University of Tokyo, and an advisor of the Japan Civil Engineering Consultants Association. He has been a professor at the University of Tokyo, supervising and teaching at the department of Civil Engineering on Spatial and Regional Planning. He obtained an engineering degree at the University of Tokyo in 1958 and began working in what is now subway operator Tokyo Metro Co. In 1966 he began his academic career, starting as an associate professor at the University of Tokyo's Institute of Industrial Science; then associate professor of the Tokyo Institute of Technology in 1970; and professor of the University of Tokyo in 1977. In 1996, he began working for the Institute for Transport Policy Studies while assuming the post of emeritus professor at the University of Tokyo. At Tokyo City University, he became a professor in 1997, president from 2004 to 2013, then president emeritus. He obtained his PhD in Engineering from the University of Tokyo in 1966 and received an honorary doctorate from Université Lumière (France), honorary doctorate from Universitaet Stuttgart (Germany), and the Dupuis Prize from the World Conference on Transport Research Society.

Kotaro Nagasawa joined the Mitsubishi Research Institute (MRI) after graduating from university and has been working at MRI to date. He has experience in research on transportation and regional planning and has served as director of departments of infrastructure research, healthcare research, personnel, and public relations. After 2 years as a president of MRI's research and development subsidiary company, he is currently a managing executive officer of MRI and the head of its think tank unit whose research business scope covers regional development, infrastructure, healthcare and wellness, global environment, energy, science and technology policy, and nuclear safety. He has published papers on infrastructure management and social security policy. He obtained his BA in civil engineering in 1983 from the University of Tokyo, an MSc from the University of Cambridge in 1990, and a PhD from the University of Tokyo in 1995.

Kazuaki Hiraishi joined the Mitsubishi Research Institute in 1984 after graduating from the University of Tokyo where he received a bachelor's degree in civil engineering, majoring in regional planning. After taking positions in regional planning, transport planning, and transport economics, he worked for the Institute for Transport Policy Studies, which is a research organization under the supervision of the Ministry of Land, Infrastructure and Transport of Japan, from 1995 to 1997. He carried out "A Study on the Indicator and Measures for Improving Urban Railways" at the Institute for Transport Policy Studies. He was awarded with a PhD from the University of Tokyo on the results of this study in 2000. After that, he has taken positions in overseas business, macroeconomics, and regional development, among others. He is now the secretary general of the Platinum Network Society.

Atsushi Hasegawa joined the Mitsubishi Research Institute (MRI) in 1993 after graduating from the graduate school of the University of Tokyo where he received a master's degree in civil engineering majoring in regional planning. At MRI, he has engaged in research and consulted on broad areas such as infrastructure planning and economic evaluation, private finance initiative/public private partnership, risk analysis and real option, food safety, active senior lifestyles, and institutional system design. He has been a visiting professor at the Tokyo Institute of Technology, teaching construction management, and was a part-time lecturer at Waseda University, teaching on real option. He obtained his bachelor's degree and master's degree in civil engineering and PhD in 1991, 1993, 2007 respectively from the University of Tokyo.

KE Seetha Ram is a senior consulting specialist for capacity building and training at the Asian Development Bank Institute (ADBI) and task manager for the partnership with the Bill & Melinda Gates Foundation. Concurrently, he is a visiting professor at the University of Tokyo, teaching and conducting research on policies and institutional mechanisms; and also advises JR East on human resources development for India's first high-speed rail. He obtained his PhD in engineering from the University of Tokyo in 1990, a master degree from the Asian Institute of Technology in Thailand in 1986, and bachelor degree from the Indian Institute of Technology in Madras in 1984. He is a fellow at the faculty of engineering of the University of Tokyo.

Chul Ju Kim is deputy dean of the Asian Development Bank Institute (ADBI). A national of the Republic of Korea, he was a secretary to the country's president for economic and financial affairs before joining ADBI. For more than 30 years he has been a key policy maker, dealing with macroeconomic, financial, and social issues. He was deputy minister for planning and coordination, director general of the Economic Policy Bureau, and director general of the Public Policy Bureau, Ministry of Strategy and Finance. He also has extensive experience in international development, specifically at the World Bank and the Asian Development Bank. He holds a BA in economics from Seoul National University, Republic of Korea, and an MS in finance from Georgia State University, United States.

Kai Xu is a research associate at ADBI and a PhD candidate at the University of Tokyo. At ADBI, his interests include multilateral cooperation and sustainable infrastructure development. He works on capacity building and training programs that provide platforms for discussion and information sharing on development practices and country experiences. He is pursuing a PhD at the University of Tokyo, where he focuses on the management of transport infrastructure. He holds a BA in civil engineering and an MA in bridge engineering from Tongji University, the People's Republic of China. Previously, he worked in the Municipal Engineering Department at Tongji Architectural Design Company in Shanghai, the People's Republic of China.

Translators and Proofreaders
Kotaro Hamada
Rika Idei
Ryo Ito
Yoko Ito
Ryuta Kuniyoshi
Takeshi Miura
Hisa Shibata
Aoi Watanabe
Naoto Yokozawa
Pei Yuxiang

Authors of the original Japanese book
Introduction: Hideo Nakamura
Chapter 1: Hideo Nakamura
Chapter2: Hideo Nakamura
Chapter 3: Kotaro Nagasawa
Chapter 4: Atsushi Hasegawa
Chapter 5: Atsushi Hasegawa
Chapter 6: Kotaro Nagasawa and Kazuaki Hiraishi
Chapter 7: Kazuaki Hiraishi

Preface to the English Edition

Though we have numerous textbooks on civil engineering, most of them present only knowledge of the design or execution of building structures. However, people who have studied civil engineering are generally involved in works of broader business related to infrastructure.

The specializations demanded by infrastructure are diverse: project conception, planning, and evaluation; fund raising; procurement of right of way; environmental surveying; design of structures; contract of work; construction management, operation, and maintenance; disaster prevention; and restoration, rehabilitation, and abolition. Students of civil engineering need fundamental knowledge of a broad scope of these topics, but few textbooks provide such knowledge.

The expert authors of this book want to share their basic knowledge of systems that govern every stage of the work of various infrastructure from gigantic airports and seaports to small public toilets in towns. High-quality infrastructure means not only being built with quality materials or technologies, but also the ability to function with high performance at every stage of the work for its whole life.

This book was originally prepared for Japanese readers. K. E. Seetha Ram, formerly at the Asian Development Bank, had the idea to let non-Japanese people who are or will be involved in infrastructure work read this book. He started to translate the Japanese version into English with the cooperation of students of the Civil Engineering Department at the University of Tokyo. He and the other coauthors of the original book, Kotaro Nagasawa, Kazuaki Hiraishi, and Atsushi Hasegawa checked the contents of the translation. In addition, Lakshmi Seetha Ram and Patricia Wada brushed up this English translation. The Deputy Dean of ADBI, Chul Ju Kim, collaborated with K.E. Seetharam and Kai Xu to contribute a new Afterword that updates the principles in a development context and outlines the most pressing challenges that lie ahead. In such a manner, this version was finished by many collaborators. I must also acknowledge Ayuko Akaike for her work to coordinate these collaborators for the translation.

It is the sincere hope of the authors of this book that it could assist readers who want to achieve the high-quality performance of infrastructure.

Tokyo, January 2019 **Hideo Nakamura**

Preface

The word "infrastructure" is currently used generally and broadly, and our lives are completely dependent on it. Nevertheless, I have never seen a book on the whole of infrastructure. Therefore, I have long had an idea to author a book on its overview.

I had given lectures to students studying civil engineering or urban planning on the topics of civil engineering planning and national spatial planning, in addition to surveying—my original specialty—for a very long time at universities. The contents of the classes were mainly demand forecasting methods for transport infrastructure planning, such as roads, railways, and the like, and methods to evaluate their economic effects. However, considering the business careers of many of my graduated students, I found that their required range of knowledge was not fully covered by such classes. They are required to have broader knowledge, even though deeply related to infrastructure. Actually, the needed knowledge spans various areas, such as the forms and functions of organizations to implement projects; the characteristics of areas and people affected by projects, land acquisition, conservation of the environment and cultural assets; and moreover, financial analysis, financing, contract types, operation of infrastructure and business expansion to related areas, participation in overseas projects, and so on.

However, I did not have enough knowledge on those topics or the ability to educate them at that time.

In Japan, infrastructure development has reached a mature stage, and its management and operation has become more important than ever before. Although infrastructure has been developed, operated, and maintained by mainly public entities, private companies have come to participate in its domestic market and to try more actively to participate in its overseas market. There have been few opportunities for these matters to be taught in universities before, and those who are involved in infrastructure-related business have limited knowledge on these matters. Therefore, I came to think that I would like to write about them as long as my resources permit.

Since I came to have time to spare for myself after retirement from all my university positions around three years ago, I thought that I could manage to organize the information that those who are involved in infrastructure at this time should study and started trying to develop the concept. I rearranged the content several times and started writing. However, to my regret, my ability to survey literature, to conduct interviews, and to concentrate on writing seems to have declined with age, and I could make little progress.

At such a time, I met Dr. Kotaro Nagasawa and Dr. Kazuaki Hiraishi, my graduated students once enrolled in my laboratory at the University of Tokyo, both currently executives at Mitsubishi Research Institute, Inc., and happened to tell them my current situation. They kindly offered to cooperate with me on my work. I was delighted to have their assistance. Further, Dr. Atsushi Hasegawa, another of my graduated students once enrolled in my laboratory at the University of Tokyo, now a young leader at MRI, joined the project.

Having strong co-authors, we reconsidered the structure of the content. As a result of consideration with Dr. Nagasawa to make the plot more systematical and comprehensive, we decided to compose the structure of the content along the chronological development of infrastructure, that is, the life cycle of infrastructure. Restarting writing like this, we made rapid progress. Moreover, the content became enriched and deepened with the three co-authors' knowledge and experience in practical business to make a survey for new business development and to give advice to various companies. One author would write a draft of his designated chapter, then other authors did not hesitate to give many opinions and suggest revisions and additions. (Each author's designated chapters are shown at the end of the book with their short biographies on pages ix to xi). We met many times and took a long time to shape the text sentence by sentence. Therefore, all of us are responsible for all the chapters. We did our best to fill the book with real examples so that readers can read with interest and understand deeply.

This book was made through this process. Many senior fellows, colleagues, and friends cooperated to find and lend us old documents and to provide us many photos, statistics, and documents. Although we should list all their names, because of the enormous number of contributors, we decided not to list them. We would like them to forgive us.

In this book, since we would like not only to show knowledge that those involved in infrastructure should study, but also to pass on a sense of responsibility and mission, we tried to describe our predecessors' various outstanding achievements as much as possible. But we could describe only a few parts of them and could not convey enough of their passion and strong will applied to infrastructure development. As many books on our predecessors' outstanding achievements are published, we eagerly wish you to read such books.

It is easily imagined that many mistakes and insufficient descriptions remain. We will revise them edition by edition according to readers' findings.

As I was writing this book, the Japan Civil Engineering Consultants Association (JCCA) helpfully provided me with a laboratory and information terminal. I truly appreciate its kindness. And I would like to express my gratitude to Mr. Yoshikazu Sakai (Infrastructure Laboratory, JCCA). He provided tremendous cooperation in editing this book.

Hideo Nakamura
March 2017
From my office overseeing Chidorigafuchi, Tokyo

Introduction

Blessed are those who find the grace in every nature. For the sake of the people and the country.

— Akira Aoyama (1878–1963), a Japanese civil engineer and leader to construct the Arakawa Drainage Canal and the Shinano River's Diversion Canal. This quote is on the inscription on the monument of the Shinano River's Diversion Canal.

The Word "Infrastructure"

It has been a while since the word "infrastructure" became popular in our society. Some people in Japan shorten it as "infra." However, there is no clear definition for it. It could be actual facilities such as roads or bridges or could be an ambiguous idea of civil engineering facilities. Those answers are not wrong, but they are not enough.

We have heard that the word "infrastructure" was first used by the North Atlantic Treaty Organization (NATO) allied air forces in the 1950s. Ground facilities including runways are necessary for air forces to function, as well as airplanes. These facilities were called "infrastructure," in contrast with airplanes. Subsequently, this collectively seems to mean not just air force facilities but social support facilities around the world.

Characteristics of Infrastructure

Infrastructure is a facility or structure established on the ground and not physically different from other properties such as residences, stores, offices, and factories. It provides goods and services for users as these facilities do. Roads provide transport service, and water systems provide water. We lump goods and services that infrastructure provides together as service of infrastructure.

Infrastructure and its services have characteristics that no other properties provide.

(i) High demand: Service of infrastructure is greatly needed in general and is difficult to be replaced. For example, water provided by a water supply system is essential.

(ii) Shared use: To own and operate infrastructure individually costs much and is technically difficult. Therefore, society must share it. For example, we have no choice but to share the source of a water facility and water main supply pipes.

(iii) Nonrivalness: Unlike general goods and services, service of infrastructure is not something that one has and others do not; as long as there is no congestion, many can utilize it at the same time without competition.

(iv) Nonexcludability: In infrastructure like ordinary roads, it is technically difficult to charge only users of the service, cars or pedestrians, and even if we did, it would lead to both direct and indirect costs, which result in huge public loss. It is impossible to charge individual users or to exclude free riders.

(v) Enormous investment: Generally speaking, it costs an enormous amount of money to construct infrastructure, and financial arrangements are impossible for a private body alone.

(vi) Decreasing average cost: In the services of infrastructure, the fixed cost like construction cost is much bigger than the variable cost, which depends on the number of service users. Therefore, the total cost (fixed and variable cost) per user gradually decreases as more people use the service.

(vii) Regional monopoly: Generally speaking, the service of infrastructure holds a monopolistic position in a region, as an investment and the operation costs are enormous, and it is utilized together in a community together. Besides, the service is essential for the users. Therefore, some public regulation is indispensable to prevent harmful effects of monopolies.

(viii) External effects: In some cases, it has indirect influences on far more people in broad areas for a long time, as well as on users who receive the direct services. For example, when a new railway is opened, not only the users but also the whole community, whose traffic becomes more convenient, enjoy its benefit and flourish.

All infrastructure has some of the characteristics shown above. That is why even in a market economy, when an investment or decision making on fees are at the sole discretion of a private sector entity such as an individual or a company, it causes a huge loss for the whole society, which results in a shortage of supply of necessary services and unfairness by monopoly. Various public involvement is necessary to work on these projects.

Types of Infrastructure

This book covers various types of infrastructure, categorized based on function.

- Community facilities
  - Water supply: sources, purification plants, distribution facilities, pipes, etc.
  - Sewerage: sewer culverts, sewage plants, etc.
  - Waste disposal facilities: incineration plants, crematoriums, etc.
  - Public restrooms

- Traffic facilities
  - Roads: traffic safety facilities, traffic information facilities, etc.
  - Railways: stations, train control facilities, etc.
  - Harbors: boating safety facilities such as sea routes and lighthouses
  - Airports: aviation safety facilities, etc.
- Disaster prevention facilities
  - River facilities: levees, groins, dams, reservoirs, etc.
  - Coast facilities: dykes, wave dissipating banks, evacuation towers, etc.
  - Fire protection facilities: fire hydrants, etc.
- Industrial facilities
  - Agricultural facilities: irrigation facilities, farm roads
  - Forestry facilities: forest roads, highlines, lumberyards
  - Fishery facilities: fishing ports
  - Industrial facilities: industrial parks, industrial water supply
- Energy facilities
  - Power facilities: power plants, substations, transmission and distribution lines
  - Gas: gas tanks, gas pipes
  - Oil storage facilities
- Communication facilities
  - Transmission, communication lines
- Urban facilities
  - Underground malls
  - Leisure facilities: parks, stadiums, etc.
- Public buildings
  - Government buildings
  - Cultural facilities: museums, concert halls, etc.
  - Social safety facilities: police stations, prisons, etc.
- National defense facilities
- Geodesic and weather observation facilities
  - Geodesic control points
  - Weather observation stations

Social Infrastructure Facilities

The various infrastructure in the above list have characteristics mentioned in the “Characteristics of Infrastructure” section and have a public character. It is not always governments or public organizations that own and operate all of these. Function-wise, they clearly have public roles, but in many cases, they are owned and operated by private companies to increase business efficiency. Even in those cases, the management is not always at the discretion of the owning and operating entities but is publicly controlled. For example, it is often the case that they need to obtain a certification for fees. And the characteristics of these facilities determine the management styles of various levels between public organizations and private companies.

According to the statistics of the national income account published by the government, investment by the government or public corporation is compiled as government-fixed capital formation, but the investments for infrastructure by private companies like railway companies are categorized as private fixed capital formation, not as a government counterpart, even though its function is public. And infrastructure owned by these companies is reported as their owned fixed assets as well as other private assets. Thus, facilities that are not classified as public assets in the national income account but whose functions are public are regarded as infrastructure in this book.

On the other hand, investment by a public body in housing is treated in the account as government fixed capital formation, but the facilities and functions of houses owned by the private body are not different from the public ones. Furthermore, some of the infrastructure systems noted above such as government buildings and cultural facilities are generally regarded as public buildings in the national income statistics, but this book does not cover them because they are the same in nature as facilities owned by a private body.

Hence, infrastructure can be defined as communal facilities or fixed assets supporting the whole of social activities, and social infrastructure seems the proper word in that sense.

Life of Infrastructure

The life or longevity of infrastructure is commonly considered as the in-service period of the infrastructure. In the case of bridges, this is the period during which a bridge is open, or the period until it becomes unnecessary or decrepit and is closed. However, the focus of this book is the period from when the infrastructure is recognized as necessary and its construction is planned, until it is placed in service and disposed of at last.

Infrastructure that a community vaguely desired comes off the drawing board into the world when individuals such as donors and entrepreneurs, private bodies, or public organizations take the initiative.

It is often the case that the concept disappears after being criticized in a conceptional phase. It took about 140 years to start the construction of diversion aqueducts in Shinano River, which were first planned by Kazuemon Honmaya in 1730. When a plan obtains broad support, an enterprising body is established, and a draft plan is materialized verifying the possibility of commercialization, source of revenue, and technical challenges. Because of its public nature, any infrastructure is required to earn public acceptance and get numerous official permissions before moving on to the next stage.

After the project is authorized, detailed investigation toward construction, design, site acquisition, and the construction contract are necessary before construction. The design is revised and new technology is introduced when needed, and it is constructed following the decided process before it can be completed.

The service of infrastructure begins to be provided only after the completion of construction. The service continues for many years, involving stable and safe service delivery, promotion of utilization and ensuring financial health, environmental conservation, maintenance, and renewal projects.

Infrastructure projects are usually lengthy. They could last hundreds of years. When you look at the modern infrastructure in Japan, the Tōkaidō Railway Line is about to reach its 150th birthday, while Asaka Canal and Lake Biwa Canal, built more than 130 years ago, function even today. Infrastructure terminates its service mostly because of innovation and social environmental change, as well as aging facilities. As was the case in the Great Wall of China, some infrastructure systems are maintained as sightseeing facilities even after they have played their primary role. In some cases, all or part of the structure is used to build new infrastructure for other purposes even if the facility is no longer necessary and is disposed of. For example, an old pier of Yokohama Port has been transformed into a modern urban district called Minato Mirai (meaning Port of the Future).

In this way, this book covers broad and long-term infrastructure projects from initial concept planning, design and construction, and operation and service, maintenance, and disposal, based on the process of the project.

Chapter

1

Various Infrastructure Systems and Their Development

Railways shorten distances, fostering the advancement and spread of culture.

— Carl Ritter von Ghega (1802–1860), Austrian civil engineer of the late 19th century, who designed the Semmering Railway, which connects Vienna with the Adriatic Sea through the Alps.

1.1 Ancient Civilization and Infrastructure

1.1.1 The Irrigation System of Mesopotamia and Dujiangyan Irrigation System of the Sichuan Basin

Ancient civilizations sprang up as settlements wherever there was a favorable environment for agriculture. Water was essential for irrigation and consumption. Water was also a means of transport. These patches of settlements grew as the infrastructure for irrigation and transport evolved. With settled agriculture, village communities became towns that later expanded into cities. To enclose these cities, defensive walls were constructed to mark and fortify their territorial boundaries. A perfect example for this is Mesopotamia. It is one of the world's oldest known walled cities.

The name Mesopotamia comes from the Greek word meaning "land between the rivers," referring to the region between the Tigris and the Euphrates rivers which is currently in southern Iraq. One of the world's oldest civilizations was born here.

The early period of Mesopotamian civilization (approximately 9000 BC) relied on rain-fed agriculture (an agricultural practice that totally relies on rainwater). Later, this arid region progressed into irrigated agriculture drawing water from rivers to fields through irrigational waterways. Sumerians, who settled southwards from north Mesopotamia in approximately 4000 BC, extensively developed irrigated agriculture up to the lower reaches by channelizing flooding waters of the big rivers. Infrastructure such as levees, canals, channels, and weirs were installed in irrigational regions. *Shaduf*[1] were used to adjust water levels, the remains of which have been excavated together with many wells. By 3000 BC, the technology for adjusting water levels according to seasons was quite prevalent. The yield of crops rose significantly, resulting in population growth and development of cities.

Increasing yields of barley and wheat in south Mesopotamia brought in revenue from exports. Vegetables such as onions and leeks were grown for export as well. Improvement in agricultural productivity and the stabilization of food supply expanded commerce, but also gave way to the growth of many city states. Uruk, a characteristic city of that time, serves as an example. Bordered by ramparts, it had public buildings and its residential area reached approximately 230 hectares. The powerful political authority of the city-states looked after and managed the irrigation and drainage systems.

---

[1] A leverage device to draw up water from a well. Made with a bucket at one end of a pole and weights at the other end.

Later, around 1700 BC, the yield of crops sharply dropped in Mesopotamia. Salt damage caused by irrigated agriculture is thought to be the likely cause. As river water flowed through the fields, due to capillary action, it brought ground salts to the surface as it evaporated. This is a universal phenomenon in arid regions. Therefore, the salinity of the soil increased with continued irrigation, affecting the yield of salt-fragile wheat. A capable labor force and a proper drainage system is imperative to the efficient functioning of this form of irrigated agriculture. After that, the irrigated agriculture of Mesopotamia eventually collapsed due to its inadequate drainage system. Eventually the Sumerians moved away from the barren lower reaches to the higher upper stream regions.

Meanwhile, in the early part of the 3rd century BC, the Qin Dynasty of what is now the People's Republic of China took advantage of the natural flow of the river, harnessing it skillfully to construct an efficient irrigation system to fertilize the vast Sichuan Basin. This system is still in use today ensuring a continuous supply of water for irrigation and drinking throughout the basin. It channelizes the water of the Min River (that which flows from the mountain range of Sichuan to the Sichuan Basin) naturally by dividing it into two rivers without using a dam to obstruct the flow of water. The Dujiangyan irrigation system came as a blessing to the Sichuan Basin, ensuring an abundant water supply and contributing to its economic development and prosperity. Even today it is the oldest surviving no-dam irrigation system in the world, boosting the prosperity of this region by constantly supplying water for the megalopolis Chengdu and irrigational water for the grand granary of the Sichuan Basin.

Dujiangyan (People's Republic of China). Waterworks facility supporting the development of Sichuan Basin from ancient times (photo by Sichuan Province Dujiangyan Management Office).

1.1.2 The Great Wall and the Grand Canal of the People's Republic of China

Nations that originated in what we refer to as the Eurasian Continent today have always been under the threat of foreign invasion. Hence, they needed to develop a defense-oriented infrastructure for reasons of national security. Although the purpose of infrastructure initially was security and governance, infrastructure for military transport was later built up to consolidate power and expand territories. The ancient People's Republic of China serves as an example.

Qin Shi Huang, the first Emperor of unified China in the 3rd century BC, carried out drastic reforms and stabilized the nation while expanding trade. Some of the far-reaching reforms included standardization of the currency; unification of the Chinese script, width of the wheel, weights, and measures; and standardization of the units of measurement—the use of a revised measuring system in which 6 feet equaled one "bu" (two paces). In addition to the unification of the writing and measuring systems, he oversaw the construction of a network of major imperial highways known as Chi Dao. The total length of the completed Chi Dao highways stretched over 6,800 kilometers (km) boosting the convenience of transporting troops and their supplies. For local administration, a new system of administrative districts was introduced, and the old feudal system abolished. Thus, he is credited to have established the system of prefectures and counties—all the officials were appointed by the emperor himself. In addition, he standardized the legal code.

Around the same time, nomadic tribes such as the Xiongnu, Donghu, and Yuezhi across the northern border were gaining strength. The Great Wall of China was conceived as a defensive infrastructure to strengthen the territory and protect the country from invasion. Qin connected, lengthened, and fortified many individual walls (the walls of the Zhao, Yan, and ex-Qin states) built at boundaries by each lord during the Zhanguo period (the Warring States period, 475–221 BC). As a result, the Great Wall of China, after linking and reconstruction, appeared as a huge structure that extended all the way from the Liaodong Peninsula in the east to the Ordos Basin in the west, its total length spanning over 2,000 km.

Early sections of the Great Wall of China during Qin's time were built at such heights that even horses could not jump over them. Basic materials such as packed or tamped earth (soil and gravel poured into removable wooden shutters) and mud bricks were mainly used. The wall was well equipped with military posts and beacon towers installed every 200–300 yards for quick communication and was designed for protection. The present-day stone-made Great Wall is the result of restorative upgrades undertaken during the Ming Dynasty (AD 1368–1644) to prevent invasion by the Mongols.

With the construction of the Great Wall of China, Qin turned his attention southward. As he launched his expedition southwards, the mountainous ranges proved difficult for the military. Therefore, he strategically ordered the construction of the Lingqu (the Ling Canal project) to ensure transport, food, and continuous supplies for the military (Figure 1.1). The canal's design is innovative: it curves through the mountains and includes 36 sluice gates with a precise control over water flow by comprehensive hydraulic facilities. Constructed in 214 BC, this waterway is 33 km long, 8–14 meters (m) wide, and 0.6–1.5 m deep. It connects the Xiang River, a tributary of the Chang Jiang (Yangtze River), and the Li River that runs into the Zhu Jiang (Pearl River). This canal links the central country to the south and was the nucleus for the water transport connecting the Chang Jiang to the sea through the Zhu Jiang. Qin made full use of it to sustain stability in the southern territory all the way to present-day northern Viet Nam.

Great Wall (People's Republic of China). The wall was conceived as a defensive infrastructure to strengthen the territory and protect the country from invasion.

Overflow dam (People's Republic of China). The dam keeps the Lingqu water level (photo by Wan Xiaopeng).

A grander canal in the Chinese continent was constructed around AD 610 during the Sui Dynasty; it is called the Beijing–Hangzhou Grand Canal. This grand canal was not fully constructed during that period. Existing portions of the canal dating as far back as the Zhou Dynasty were linked into a unified system that stretched to an approximate length of 2,500 km. As it connected northern China to the southern Yangtze, it integrated the north and south, forming the basis for a unified national economy. As the oldest and longest canal in the world, with a history

Grand Canal (People's Republic of China). Going back over 1,400 years, this is the world's oldest and longest canal (photo by Yan Wanglin).

Figure 1.1: Location of Lingqu and Grand Canal

of over 1,400 years, it is operational even today and is listed as a United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Heritage Site.

1.1.3 Roads, Ports, and Aqueducts of the Roman Empire

As ancient civilizations expanded their territory, they built an extensive network of roads. As towns expanded, various infrastructure to support the growing populations also came up. Ancient Rome is a perfect example of a prototype of urban development and urban infrastructure construction. Its rich legacy of invention and innovation can still be seen today.

The city state of Rome arose from a small town in Central Italy and in the course of centuries grew into a vast empire reaching its zenith of prosperity around the 3rd century AD (Figure 1.2). Its vast empire embraced most of England to the whole of southern Europe, as well as territorial holdings around the Mediterranean Sea in Europe, Africa, and Asia. Ancient Romans were prodigious builders and engineers. Known for their remarkable engineering feats, they constructed an impressive network of roads and bridges, aqueducts, ports, coliseums, opera houses, and temples throughout. It is believed that Roman engineering accomplishments generated much wealth and prosperity, improving the daily lives and culture of Romans while helping maintain their dominance for centuries.

Major sections of roads were standardized in 4-m widths with side strips on both sides, paved by stacking stones of different sizes. Some segments of the roads such as the Appian Way (completed in 312 BC connecting Rome to Brindisi south of the Italian peninsula) have been located as historical remains. Some portions are operational even today in many parts of Europe with proper maintenance and repair. Roads were built with adequate bridges made of stone arches and short tunnels. The coverage of arterial roads around the 4th century AD spanned over 80,000 km. The robust extensive road system facilitated movement of troops and communication, contributing to the economic prosperity of the Pax Romana.

At the time of the Roman empire, people mostly lived on highlands. Therefore, they had an advantage in terms of sanitation and military capabilities. Over time, these highland settlements evolved into cities. As cities grew, they needed advanced water supply facilities. Long-distance aqueducts and culverts were constructed to ensure fresh water supply. Some portions of these prominent, elevated long-distance aqueducts with distinct stone arches are intact even today. Though these structures are approximately 2,000 years old, their remains continue to inspire

Figure 1.2: Road Network of the Roman Empire

Appian Way (Italy). Completed in 312 BC, some parts are operational even today (photo by Shigeo Hatsushiba).

Pont du Gard (France). This ancient Roman aqueduct crosses the Gardon River in southern France (photo by Shigeo Hatsushiba).

architects and engineers. The longest aqueduct in Carthage (Tunisia in north Africa) exceeds 130 km in length. The Roman empire flourished due to its sophisticated infrastructure of aqueducts covering long distances. They had an extravagant water supply for public amenities including public bathhouses, suggesting that their water capacity was perhaps much more than what we have today.

In addition to these, they had a rich and extensive infrastructure: paved road networks, water supply systems, sewage systems, temples, and many more. Although the catastrophic volcanic eruption of Mount Vesuvius in AD 79 buried Roman settlements, archeologists are investigating the remains of Pompeii, an ancient city discovered 200 years ago that offers a unique window into the ancient world.

Many ports were constructed along the coast of the Mediterranean Sea enabling transport of goods throughout the vast Roman empire. For instance, the city of Ostia (25 km downstream from Rome on the Tiber River) became prominent because of its sea port at the mouth of the Tiber River. Ostia was built as a harbor city; its hexagonal port is enclosed by a stone embankment embracing a broad water surface. This port provided Rome with vital supplies and served as the main point of transfer of goods and grains from areas of production.

By utilizing cement—invented by them—the Romans filled interstices between the stone slabs and stacked them up to form firm arc-like structures. This freedom of concrete inspired various infrastructure throughout the Empire, ensuring prolonged prosperity. These were passed down through the Medieval Ages to modern Europe, greatly influencing the form and technology of modern infrastructure.

1.2 Development of Nations in the Medieval Ages: Early Modern Period and Infrastructure

1.2.1 City Ramparts of Europe

In medieval times, many Eurasian cities were still under threat of foreign invasion. Hence, defensive walls or ramparts became a common feature in areas vulnerable to attacks. These defensive infrastructure systems gave rise to "fortified cities," distinctive of 10th–12th century Europe.

Many European cities originated in areas where Roman troops sheltered. Around the 5th–10th century after the gradual disintegration of the western Roman Empire, foreign invasions became a common occurrence. People fled from vulnerable cities to safer rural areas. Gradually, aristocrats from these newly populated regions established feudalism based on estates and manors.

After the 10th century, the new cities became populated due to improvements in agriculture, reduced foreign invasions, and enhancement of trade and commerce. With concentration of wealth in cities, rulers invested in defensive ramparts for security.

Cities with ramparts were designed in such a manner that entry and exit could be monitored—it was restricted to castle gates. Another defensive strategy was to dig moats and build drawbridges over them. Military infrastructure included watchtowers at regular intervals along the ramparts. Watchtowers were built with embrasures that could allow weapons to be fired undercover from within the fortification.

Carcassonne (France). This medieval walled city continues to enchant tourists as proof of one of the largest fortified cities.

Urban castle gate of Valencia (Spain). The walls no longer stand, but the castle gate remains (photo by Yūichi Nakamura).

Carcassonne in southern France continues to enchant tourists as proof of one of the largest fortified cities. Surrounded by 15-m-high dual ramparts extending up to 3 km, this hilltop city with 53 watchtowers is an outstanding example of a medieval fortified town. As the perimeter of the city of Paris grew, ramparts were extended radially and successive defense structures improved upon. Vienna, a city that withstood sieges of the Ottoman Empire twice, also had towers and fortresses in addition to a deep moat and ramparts extending to a length of 4 km. The Dubrovnik ramparts of Croatia stand out as one of the grandest fortified monuments in Europe. The wall is 23–25 m high in some parts and 3–6 m thick. It extends over 2 km, giving the impression of an impregnable city facing a mountain on the north side and surrounded by the sea on all other sides.

The escalating cost of construction and maintenance meant that only a few cities could afford to build permanent ramparts. Historical records reveal that only 576 (53%) of 1,083 cities in Germany had defensive walls. Cities with a population of over 3,000 or more were fortified; but the percentage dropped to 43% for those cities where the population was less than 1,000. It is noteworthy that 57% of the cities with a charter[2] had walls; the figure stood at 41% for cities without a charter.

---

[2] A charter is an official document published by kings or lords to indicate autonomy (such as freedom of commercial activities) being transferred to citizens. By granting the right of self-government (right of taxation), the cities were constructed with citizens' own expenses.

Box 1.1: Temples and Churches as Infrastructure

Sacred, religious, and holy structures evolved over centuries as crucial components of towns and cities worldwide. Temples and shrines serve as places of worship in Japan; similarly, churches form the core of religious infrastructure in Christian countries.

Japanese lifestyles are closely linked to local temples and shrines. People visit temples and shrines on certain days of the year coinciding with tradition or life milestones. Not to be missed is the customary *hatsumōde* (the first shrine visit of the new year); *Setsubun* (the day marking the end of winter in early February); *Higan* (equinoctial week-long observance in spring and autumn); *Bon* (paying tribute to deceased relatives and ancestral spirits in mid-August); as well as turning points in life such as *Shichigosan* (celebration of children aged seven, five, and three), weddings, and funerals. During the Edo period, as the *terauke* system (a citizen registration network) was created, census registrations were virtually managed by temples and shrines. They also constructed and managed cemeteries, safeguarding the link between inhabitants and ancestral spirits.

Historically, churches and schools responsible for religious studies in many Christian countries, such as some in Europe, were strategically located in the geographic center of the city or region. The prime aim was to promote fellowship within the community through regular worship or visits. Japanese temples and shrines played a similar role. People used to convene in sacred places for ceremonial events such as weddings and funerals. The parish church served as the basic unit of the Christian community, offering the sacraments required by the lay community. Churches played a significant role in service activities such as poverty relief. If someone committed a crime, the church served as the place for confession and forgiveness too.

Thus, religious facilities shared by the community may be regarded as the infrastructure for spiritual well-being. Because of the unique position and profound influence of the church on the social fabric, public organizations in several countries continue to engage with and manage them.

Chartres Cathedral (France). Completed in the 13th century, the Chartres Cathedral was a pilgrimage destination and is now a UNESCO World Heritage Site (photo by City of Chartres, Guillermo Osorio).

Hagia Sophia (Turkey). Built in the 6th century in Istanbul, the Hagia Sophia has served as a church, a mosque, and a museum over the years. It is also a component of a UNESCO World Heritage site, the Historic Areas of Istanbul.

Geographically, a higher concentration of firmly fortified cities was found in the more urbanized western parts (Flanders, Rhineland, Hesse, Saxony) and frontiers (lowland regions) that had been exposed to warfare. Over the ages, city ramparts became unique inheritances giving a clear definition to the city form while invoking a sense of civic pride among the inhabitants.

Advances in modern warfare made large-scale fortifications obsolete over time. The reach of artillery and air power meant that the tactical use of ramparts declined. In the 20th century, as the population grew, many walls in Europe were demolished one after another. In some places, although walls were destroyed, the remains were improvised for use as railways and highways. The "ring roads" of Paris and Vienna serve as examples.

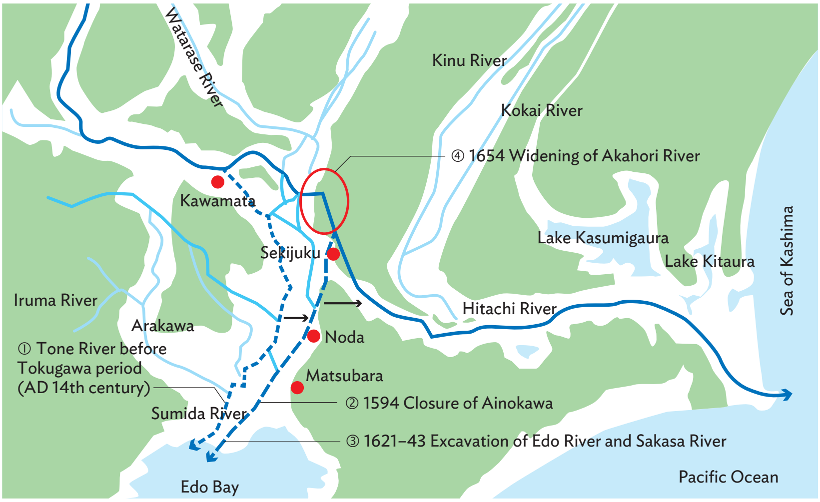
1.2.2 River Projects of Japan in the Early Modern Period: Eastward Shift of the Tone River, Separation of the Kiso Three Rivers, and Relocation of the Yamato River

In Japan, after the Sengoku (Warring States) period ended, political stability improved. Iyeyasu Tokugawa (1543–1616) assumed power and established his shogunate in Edo. The Tokugawa Shōgunate (also known as Edo Bakufu) was the federal government among all the regional daimyō (Japanese feudal lords) around the country. Politically it was a centralized system; the central government had absolute power over the han (local governments). Economically, it was more decentralized. The han could decide tax rates and other economic regulations. The shogunate and daimyō actively supervised river improvement projects to secure territory and imposed financial expenses on the han, thereby controlling their economic development.

In the Edo period (1603–1867), the shōgunate, feudal domains (han), villages, and the like oversaw improvement works, depending on the scale and magnitude of work. The wide-ranging river improvement projects of that time created the foundation for the development of the three metropolitan regions of today (Tokyo, Osaka, Nagoya).

In the Kantō Plain, Ieyasu Tokugawa, as the first shōgun, began work to divert the Tone River to protect the Edo area (now Tokyo). The Ina family was given the responsibility of diverting the river eastwards to Chōshi, 90 km east of the original mouth. Until the diversion, it had flowed into Tokyo Bay. This is known as the eastward shift of the Tone River, which took place around the end of the 16th century to mid-17th century (Figure 1.3). The river refurbishment project included installation of water sluice gates called *iri*, construction of Kasai Canal,

Figure 1.3: Geographical Changes of the River Channel of Tone River (Japan)



Source: Created based on the Ministry of Land, Infrastructure, Transportation, and Tourism.

and excavation of diversion channels. The entire network of waterways was under direct control of the shōgunate. For overflow prevention, a retarding basin was fashioned on the left bank, the opposite side of Edo Castle.

In the early part of the 17th century, in the Nōbi Plain, a 50 km-long continuous levee called Okakoi Tsutsumi was constructed on the left bank of the Kiso River (the Nagoya Castle side) from Inuyama, a mountain in the north, all the way to the river mouth. The Ina family was tasked to oversee this project of the Tokugawa Shōgunate (Tadatsugu Ina, the governor of the Bizen region). The intention was to protect castle towns of the Owari region from flooding. Water drainage channels were installed on the left bank and a network of irrigation canals (Miyata Canals) were constructed to improve agricultural activities in the Nōbi Plain. Breaking off from conventional practice wherein farmers normally managed water channels, the Owari Han (Owari Domain) directly controlled these canals. Levees on the right bank were kept lower than those on the left bank—the design helped flooding water to overflow onto the right side, the opposite area of the castle town. Thus, a unique flood-preventive community surrounded by levees called *waju* was created on the right bank.

These river improvement techniques implemented on the Kantō and Nōbi Plains came to be known as the *Kantō-ryū* (Kantō Style) or

*Ina-ry*ū (Ina Style). The uniqueness of this was that it followed the natural meandering of the river water utilizing natural land characteristics while building reservoirs, *kasumi-tei* (open levees), farmlands outside of levees, and retarding basins to disperse floods by allowing inundation to some extent. The overflow was expected to bring in richer soil and benefit farming. It is believed to have its origins in the *Koshu-ry*ū (Koshu Style, representative work: *Shingen Tsutsumi* [Shingen Levees]).

Meanwhile, another improvement project on the Yodo River in the Osaka Plain made use of the *Kishu-ry*ū (Kishu Style) that straightened the river channel by reinforcing levees on both sides to rapidly discharge floodwater. Under the supervision of the shogunate, at the end of the 17th century, engineer Zuiken Kawamura excavated Kujojima (Kujo Islet) for managing the Yodo River. The newly excavated river came to be known as Aji River. It was fashioned by straightening 3 km of the old river channel to prevent flood damage at the lower reaches. Following this, the Yamato River was separated from the Yodo River so that it could directly discharge into the Osaka Bay through a 14.5-km-long, 180-m-wide canal. Former riverbeds and floodplains at meandering points were used for rice cultivation. By then, the population of the Kinki (Osaka) region had increased; it was much higher when compared to the Kantō (Tokyo) and Chūbu (Nagoya) regions. Hence the Kishu-ryū of river management proved successful given that more land was available for agricultural use near the river.

Since then, the Kishu-ryū became the preferred choice over the Kantō-ryū as it was perfectly suitable to its time. In the Kantō style, river banks were constructed such that they could withstand small and medium sized floods. Water was allowed to overflow through cultivated fields and temporarily collected in a pond during large floods. When the flooding subsided, it was drained back into the river.

The Kishu-ryū called for banks to be high enough to prevent flooding and adjacent land was used for agriculture. Each style left its mark on water management projects. Early in the 18th century, the shogunate adopted the Kishu-ryū for managing the Tone River. Meandering river channels were straightened and continuous levees were constructed. Improvement works included removal of reservoirs and separation of irrigation and drainage water. The Minumadai Canal and Kasai Canal were connected to promote land reclamation and paddy cultivation at impeding basins both in the middle and delta regions of the lower reaches.

In the mid-18th century, the Tokugawa Shōgunate ordered Satsuma Han (Satsuma Domain) to carry out challenging river engineering works (*Hōreki-chisui*). Rivers that caused frequent floods included the Kiso River, Nagara River, and Ibi River near Nagoya in the Hōreki era. The

Nōbi Plain river improvement involved separating these rivers. The Satsuma Han were forced to shoulder the entire finances for this project, and many of them died during the construction. It was finally completed in the Meiji era. It is based on a proposal by Yasobe Izawa of Kishu-ryū.

The water management projects of 17th–18th century Japan illustrate how much they have contributed to mitigating flood damage and improving agriculture in the Kansai (Osaka) and Chūkyō (Nagoya) regions, paving the way to the modernization of Japan since the Meiji era.

1.2.3 Land Reclamation of the Netherlands

Technical advancement in infrastructure not only involves efficient land utilization but lies in creating land itself. Throughout the course of history, the Netherlands has been reclaiming land to gain space for its residents.

The word “Netherlands” refers to a nation of lowlands; 30% of its entire land area (over 40,000 km^2) lies below sea level (Figure 1.4). The lowest site has an altitude of about 6.7 m in the vicinity of Rotterdam.

In the past, the Netherlands was mainly wetlands, consisting of swampy, peaty marshland with an altitude of just 1–2 m above sea level. In an effort to control and conquer the landscape, the Dutch enclosed the wetlands with levees and reclaimed farmland by gravitational drainage. The oldest levee dates to the Roman Empire, and the first land reclamation was carried out around the 10th century.

More than 3,000 polders (reclaimed lands) are in place across the country. *Waterschappen* (water boards) are the oldest governing body in charge of constructing and managing polders. Although it is an autonomous organization, a *waterschap* is responsible for collecting taxes for maintenance of levees and plays a significant role in the security management of local regions in the Netherlands even today.

However, with construction of defenses for flooding and land reclamation, drainage became increasingly difficult as most of the polders were below sea level. For this purpose, windmills were used as a power source for pumping water early in the 15th century. Large-scale land reclamation improved by the end of the 16th century, owing to improved windmill designs. The Beemster Polder is an exceptional example of land reclamation (7,174 hectares) dating back to the 17th century. After the construction of a ring dike, several windmills were used to pump water out of Beemster, creating new, empty land. A pattern of squares formed by water courses and roads was laid out. This exceptional land division has been conserved almost untouched, deeming it the status of a UNESCO World Heritage Site. Technical improvements in windmill technology thus increased profitability of land reclamation

Figure 1.4: Areas Below Sea Level in the Netherlands (Dark Green Areas)

projects, encouraging investment and offering stimulus to further land reclamation projects.

After the 19th century, steam pumps, followed by electrical pumps, came into use, expanding infrastructure projects. Reclaimed land area dramatically increased. According to historical records, 4,625 km^2 of land was reclaimed within a span of 700 years (between 1201 and 1900). Today land reclamation stands at over 8,000 km^2.

Polders have a high ground water level yet very low humidity; this is suitable for dairy farming. Areas with excellent drainage were used for farming vegetables and horticulture. After 1970, the focus shifted to using more land for residential and industrial purposes, as well as for forestry and recreation.

It takes about ten years after drainage for reclaimed land to be ready for farming. A typical government project consists of the following steps. After drainage, the first step is to desalinate the soil by rainwater. The next step involves growing reeds until the moisture content of the soil evaporates. Following this, the reeds are burnt away, and drainage

IJsselmeer (Netherlands). This lake used to be part of the Zuiderzee sea inlet. It now functions as a freshwater reservoir and is used for transport, fishing, and recreation (photo by Shigeo Hatsushiba).

canals are dug. After the soil is rendered more permeable to air, it is well plowed for oxidation. Finally, winter wheat is grown and then handed over to farmers.

The largest land reclamation project was the Zuiderzee Works (5,000 km^2), an enclosed bay of the North Sea, north of Amsterdam. An enormous levee 8 m high, 90 m wide, and 32 km long was erected in such a manner that it was no longer a sea inlet. Between 1927 and 1932, the continued flow of river water flushed out the salt water; the former bay was transformed into a freshwater lake, renamed as the IJsselmeer.

From 1929 till 1967, over half of the IJsselmeer was drained, creating 1,979 km^2 of four polders: Wieringermeer Polder, Noordoost Polder, and East and South Flevoland. Although much of the drainage was completed by 1968, most of the land remains vacant, reflecting the Dutch style of taking time for land development.

During the early stages of the Zuiderzee Works, the plan was to construct five polders within the IJsselmeer. However, due to environmental issues, the government withdrew the drainage plan of the fifth polder, Markerwaard, in 1991. Thus, the remaining lake, Markermeer, which is split from the Ijsselmeer by a dike, functions as a repository for wild birds and freshwater fish. The closing levee continues to be utilized as a regional access road.

In this manner, over time, with its strategic water management and land reclamation processes, the Netherlands evolved into one of the world's leading economies.[3]

---

[3] Ranked 12th for GDP per capita in 2014 ($51,000).

Box 1.2: Goethe's Faust and Other Reclamation Works

"Stay a while, you are so beautiful!" whispered Dr. Faust as he fell. The ghosts embraced him, laying him on the ground.

This is a well-known scene from *Faust*, an influential play written by the great German writer Goethe and an interpretation of the Faust legend that has inspired many musicians, writers, and other artists. Faust dominated much of Goethe's intellectual life. He did not complete the play's final act until a year before his death, 60 years after he first began. In the play, Dr. Faust describes his areas of instruction, "Alas, I have mastered philosophy, jurisprudence, medical science, and theology, but I am filled with despair and discontent." In the play, the demon Mephistopheles cunningly sways him to disregard his values and pursue the pleasures of the flesh. Faust makes a pact with the demon, who offers to serve him at the cost of Faust's eternal soul! The demon, in the form of a black dog, appeared in front of him and made the pact in a cunning manner.

Demon Mephistopheles: "I can grant all your wishes on this Earth, but in return, you have to serve me in the netherworld."

Dr. Faust: "If you satisfy me, and fulfill my wishes, I shall accede by saying 'Stay a while.' Then, that moment shall be my last moment in this world."

Following this pact, Mephistopheles lured Dr. Faust into tricks, tales, and temptations! Faust indulged in all kinds of pleasures: seduced the pure and pious Gretchen and destroyed her life, drowned himself in intoxicating liquor, abused his authority by corrupt and criminal means. Faust's cravings worsened as he became an unstoppable Napoleonic figure. Combined with the demon's lethal power, his reckless attitude and appetite for power and pleasure was unstoppable. According to Goethe, Faust took part in national administration during his final days and worked on land reclamation. Blinded by the work of the devil, Faust mistook the sound of the demon's servant digging his grave as progress on a land reclamation project. He promptly gave in, whispering the words he had promised earlier... and passed away.

The ultimate moment for Dr. Faust (who did not gain any happiness despite all the pleasures of the world) was when he thought that the sound of the hammer was that of the land reclamation work. Imagining that the completion of the project would help several thousand and liberate himself too, the spirit of Dr. Faust eventually found redemption along with his beloved woman's prayer.

Goethe's interpretation implies that professions related to infrastructure works may be the panacea for redemption from the Faustian bargain!

1.2.4 Maps and Control Points in France

At the onset of the Age of Exploration, in the early 16th century, inquisitive and financially motivated Europeans were travelling outwards across the globe. These explorers needed navigational guides in line with colonial expansion. Therefore, there was a pressing need for precise maps. Triangulation methods that are very much in use all over the world stem from the works of mathematicians and cartographers in France around the 17th century.

Jean-Baptiste Colbert (1619–1683) served as the Minister of Finances under the rule of King Louis XIV. Through Colbert's influence a landmark engineering work was completed in France at that time. It was the construction of the remarkable Canal du Midi (Midi Canal) linking the Atlantic with the Mediterranean. In 1668, Colbert appointed astronomer Jean Picard (1620–1682), who was a founding member of the French Academy of Sciences, for further work on geographical coordinates.

Although Gemma Frisius of the Netherlands gets the credit for the basic principles of triangulation survey (which was the latest technology during the 16th century), its practical application was limited due to several shortcomings. Jean Picard developed an arc instrument that is modern in some respects. He measured a baseline by the aid of wooden rods, used a telescope in his angle measurements, and computed with logarithms. In this manner, using a plane table or theodolite, he achieved a high degree of accuracy.

So, the scientific survey of France was initiated by Jean Picard in 1668 when he first used triangulation for mapping land territory. After measuring the whole land of France by this method, he defined a meridian through Paris and continued to triangulate distances to the coast.

Mapping longitude had been tricky too. The Italian mathematician and astronomer Jean Dominique Cassini (1625–1712) was brought in to collaborate with Picard. Cassini made good use of a method using observations of Jupiter's moons, first suggested by Galileo, who discovered them. He showed how this method could be used with telescopes mounted on the ground. His team began to map the east-west boundaries and then the whole of France based on the meridian (north-south line), with which the chief instrument of the Paris observatory was aligned.

With an ambitious start in 1683, they first set the triangulation chains from south to north, then west to east, finally covering all of France. After Cassini, the work was carried out by his son and grandson; it was finally completed after 62 years in 1744. The total number of chains was eight hundred. It shows the meridian running down the center of France, the observatory appearing as the beating heart of the whole.

The third-generation Cassinis carried out land surveys, but this was no small feat. When the Seven Years' War started in 1756, financial support for the project was withdrawn. With the help of investors, Cassini's team surmounted these obstacles and continued the detailed surveying even during the French Revolution. The fourth-generation Cassinis managed to create a full comprehensive map of the whole territory of France. In 1793, they completed 182 large-scale terrain maps on a scale of 1:86,400, nearly 110 years after the project started in 1683.

These maps, dubbed the Cassini Maps after the great work by the Cassini clan, are the first terrain maps based on the scientific survey (Figure 1.5). They formed the basis for many future maps because they contained all the topographical features such as rivers, embankments, roads, canals, buildings, and even a vineyard!

In the case of Japan around the same period, Tadataka Inō is credited to have completed his masterwork, the Dainihon-Enkai-Yochi-Zenzu (map of the entire Japanese archipelago) and submitted it to the government. It was published posthumously in 1821. Modern

Figure 1.5: Cassini Map: First Topographic Map of an Entire Country (France)

cartographic technologies including triangulation came into Japan after the Meiji Restoration in 1868.

Cartographers have been widely using triangulation techniques for surveying and mapping since the 19th century. Datum levelling was fixed by the imperial army in Japan in Miyakezaka, Tokyo, based on tidal observations of Tokyo Bay. There are about 17,000 benchmarks connected to this datum point. These benchmark control points that are fixed across the country are based on continuously operating reference stations (CORS) and triangulation points, which in turn are based on latitude/longitude and elevation information. This forms the basis of all construction and planning. Now the Geospatial Information Authority of Japan (GSI) sets and maintains all control points.

Nowadays, most of the information is digitized and getting replaced by the global positioning system (GPS). Japan has over 1,300 electronic control points connected with GPS for efficient surveying. "Digital Japan" information has a lot of potential and a wide range of applications. Specifically, it will be of immense help in supporting disaster prevention and monitoring environmental changes.

A permanent GPS monument in Japan. The information these structures help to collect has many uses (photo by Geospatial Information Authority of Japan).

1.3 Infrastructure of the Modern Period

1.3.1 Invention and Growth of Railways

The Industrial Revolution brought about significant innovations in infrastructure. The invention of the steam engine stands as the icon of the Industrial Revolution. The improved systems of transportation brought speed and dynamism, distance that could be covered more quickly, and a high volume that could be achieved. All of these improvements combined offered further stimulus that helped transform world trade and laid the foundation for global modernization.

An impetus for initiating this trend was the construction of British railways. In the early 1800s, British engineer Richard Trevithick (1771–1833) constructed the first railway steam locomotive. Until then, raw materials and goods used to be transported by horses running on gravel-paved roads. In 1825, the Stockton & Darlington Railway (S&DR) began as the first railroad operating the first railway route (40 km) by steam locomotives in northeast England. The intention was to connect the inland coalmine of Stockton to Darlington's port. Later in 1830, the Liverpool & Manchester Railway (L&MR) started to operate a 56-km-long route, northwest of England. The purpose was to transport a large amount of textile materials unloaded at the port of Liverpool to Manchester and its surrounding industrial areas. The fares were

Sankey Viaduct of the Liverpool and Manchester Railway (United Kingdom). Completed in 1830, it is still in service (photo by Shunsuke Baba).

cheaper than horse drawn carriages, so passenger transport increased too. Indeed, until the 1840s, railways made more profit from passengers than freight as the rail networks increased, connecting major cities. The population of transported passengers increased from 27,760,000 in 1844 to 288,630,000 in 1870.

Early railway tracks were laid on level surfaces and gentle slopes with fewer curves as it was difficult for steam locomotives to climb up steep slopes. Therefore, one of the techniques used to avoid steep inclines was to use more tunnels and bridges. To compensate for changes in elevation, the direction of tracks was reoriented and the design of tunnels and bridges improved.

Railways spread to neighboring European countries too. Germany's first steam driven railway opened in 1835, an 8-km stretch linking Nuremberg to Fürth. Within 20 years, by 1855, Germany had a total of approximately 8,000 km of railway networks. In France, a 58-km-long railway connecting Saint-Étienne and Lyon was opened in 1832. The design of the first lines (a seven-line radial network), radiating out of Paris and connecting France's major cities to the capital was finished by the 1860s. In 1870, it covered almost 23,300 km.

As for the United States, railway construction started in the eastern regions from the 1830s. The first transcontinental railroad system connected New York and Chicago in 1852; then, it extended to connect Chicago and San Francisco across the Rocky Mountains in 1869. By 1890, the whole nation was connected by the rail system extending over 250,000 km, reaching up to 400,000 km in 1914. These coast-to-coast railroad connections run by private operators revolutionized the economy, giving rise to many townships connecting cities in the West.

In Japan, the first railway opened between a stretch of 29 km connecting Shimbashi to Yokohama in 1872. The Tōkaidō Main Line connecting Tokyo and Kōbe came into service in 1889. The United Kingdom proceeded with the construction of railway networks in its colonies. In India, the construction of railways began in the 1850s. In 1902, the railway mileage stood at 40,000 km, serving almost 200,000,000 passengers and carrying 46 million tons of goods.

Later, railways became the preferred mode of transport for people in the metropolitan areas. The first trams ran on the streets of Berlin in 1865; elevated railways came about in New York around 1871 in the urban areas. The first underground steam locomotive opened in London in 1863, but it was not until 1898 that electrified locomotives came into operation.

In this manner, in the 19th century, once railways became the fastest means of communication and transport, new economic opportunities opened. It spurred the advancement of mechanical engineering and civil engineering technologies. In the metropolis, magnificent stations showcased prosperity and power.

Around the middle of the 20th century, with the burgeoning automobile industry, construction of railways was vastly delayed due to road construction and growth of automobile-based industries. An efficient and secure rail transportation system meant that residential and commercial complexes could flourish in areas away from the city centers. This triggered another wave of urban development in the late 20th century, bringing about a boom in civil engineering projects such as public/private rapid transit systems around the world.

1.3.2 Development of Modern Transportation Network: The Suez Canal and the Panama Canal

Despite technological advances in land transport, water transport is much more efficient, economical, and suitable for heavy cargo. Hence after the Medieval period, many canals especially in the low-lying areas of European countries were dug inland, connecting to the rivers and seas.

In 1694, the Canal du Midi, considered to be a masterpiece in French engineering, was completed. It is a 240-km-long canal that directly connects the Mediterranean to the Atlantic, avoiding a vast detour around the Iberian Peninsula controlled by Spain. Given the undulating terrain, over 100 lock gates were fixed to make navigation easier.

In the middle of the 19th century, the French diplomat Ferdinand Marie Vicomte de Lesseps (1805–1894) launched a project to connect Europe, India, and Asia without having to go all around the southern part of Africa. The idea was to construct a canal across Isthmus of Suez in Egypt. This ambitious project needed massive digging and extensive labor. The Suez Canal finally opened in 1869—four years behind schedule. Major improvements began in 1876; since then, after several extension works, the Suez Canal has developed into a 193-km-long, 205-m-wide, 24-m-deep grand canal that transports almost 70% of the petroleum consumed in Europe.

In the 20th century, the construction of the Panama Canal began. Led by the French diplomat Lesseps (the builder of the Suez Canal in Egypt), the construction team found it to be a monumental challenge. The idea was to create a water passage across the Isthmus of Panama to link the Atlantic and Pacific Oceans. The project suffered a setback due to the mountainous and jungle terrain, tough geological conditions, as well as prevailing epidemics. The French handed it over to the United States, and it was finally completed in 1914.

Suez Canal (Egypt). A container ship sails on the canal (photo by Ministry of Foreign Affairs Japan).

The Panama Canal extends 90 km. Water levels are elevated from the level of the Atlantic Ocean in one three-step set of locks at the highest point of Lago Gatún (Gatun Lake, which is in the middle section of the canal) and then the water drops, likewise in a three-step manner, to the level of the Pacific Ocean. Because of this, six lock gates were installed to enable ships to climb over the mountain on a "stairway of water."

The original design of lock gates limits the size of the ships to what is known as the Panamax size (294 m in length, 32 m in width, 12 m in depth). Due to the growing demand of maritime trade and use of larger vessels, expansion works were initiated. This included construction of

Panama Canal's Gatun Locks (Panama). The lock system allows ships to travel up and down the canal (photo by Panama Canal Authority).

a new set of locks as well as improvement of navigational channels and water supply. The entire project was completed in 2016. Currently, the waterway can accommodate the Neopanamax size (366 m in length, 49 m in width, and 15 m in depth), enabling the smooth sailing of larger ships.

The opening of the new Panama Canal shortened the sailing distance between Europe and the west coast of the United States by approximately 40%; it also shortened the distance between the east coast of the United States and the east coast of Asia by about 30%. From the viewpoint of global logistics, it has had a huge economic impact and drastically improved marine transportation.

1.3.3 Construction of Parisian Streets and Japanese Cities

Even after the 19th century, many European cities were overcrowded, dark, and dingy with complex street shapes and poor sanitation. Paris was not an exception to this. During the Second Empire (1852–1870), Georges-Eugène Haussmann (1809–1891), the governor of the Seine Department, was commissioned by Napoleon III to transform the city.

He became one of the most prominent and controversial planners in history. He transformed Paris by modernizing the cityscape, replacing the crowded streets with wide-sweeping boulevards, expansive parks, and squares and refurbishing rundown buildings with bourgeois apartments.

Haussmann installed a sensational network of a dozen colonnade-planted avenues, such as the 70-m-wide Champs-Élysées, radiating from the Arc de Triomphe at the core of Haussmann's Place de l'Étoile. These radiating avenues edged with trees and stone buildings connected the narrow streets of medieval character. The heights of the buildings facing the streets were pre-determined depending on street widths. Architecture was eclectic; styles were chosen to suit the function of each building. Regulations were put in place for the height and number of floors for each building, style of roof, and specific use of construction materials for the exterior (use of stone was preferred). Embellishing the city with Renaissance facades, his goal was to create a harmonious, solemn, beautiful cityscape of Paris. Large recreational public parks such as the Bois de Boulogne and Bois de Vincennes, as well as small to medium sized parks were carefully designed in places all over the city.

Streets were realigned and paved to create land for other uses. Meanwhile, a speculative bubble of land asset value was also discouraged. Since Haussmann's city reformation tactics were coercive in nature, this incurred the ire of the city's inhabitants. The financial resources for this project came from diverse corners—national bonds as well as gains from selling the confiscated property of aristocrats and churches during the French Revolution. Although Hausmann was never celebrated during his time, he is credited to have transformed the city of Paris as *La Ville-Lumière* (the City of Light). Hausmann's approach greatly influenced urban development projects in other countries, such as the *Ringstraße* (Vienna Ring Road) and the land readjustment project of urban Barcelona.

Despite admiration for Parisian restructuring, Japanese cities favored a more pragmatic approach. Except two or three, most Japanese cities have not gone through extensive systematic street development projects. Most have merely undergone land readjustment projects especially in low-lying areas (*shitamachi*) of eastern Tokyo after the Great Kantō Earthquake. The Post-War Reconstruction Project after World War II was a perfect opportunity for many cities to plan systematic street networks and parks. Due to limited financial resources, however, many of them failed to achieve systematic development. Sendai, Nagoya, and Hiroshima are examples where systematic urban development projects such as widening of streets have been implemented. Besides these, Toyohashi, Toyama, Fukui, Sakai, Himeji, and Kagoshima also underwent widening of existing streets and creation of wide boulevards and downtown parks, thereby contributing to the welfare of citizens.

Speaking of wide streets in Japan, Ōdōri Boulevard (Sapporo) deserves special mention. Chiefly planned by an American advisor, the street network that forms grid-shaped city blocks demarcates the city into east and west by the Sōsei River; into north and south by the 105-m-wide Ōdōri Boulevard. Ōdōri Boulevard has its origins as a park in 1911. Later on, during World War II, the park was used for potato

Ōdōri Park (Japan). Rare among Japanese cities, this park in Sapporo has wide streets.

production. After the war ended and food supply improved, it became a garbage dumpsite. Fortunately, the central space of the boulevard was refurbished as a park again after 1950, eventually becoming a treasured area for relaxation in downtown Sapporo. In addition, the Sōsei River that divides central Sapporo into eastern and western halves has been developed into a waterfront park thanks to the construction of a river underpass. This waterfront park has blossomed into a precious healing space for the metropolis.

1.3.4 Lake Biwa Canal, an Infrastructure System That Led to the Modernization of Japan

Shifting toward modernization, Japan opened itself to Western influence and invested in infrastructure aggressively during the Meiji period (1868–1912). During the early part of the period, Japan introduced technology from Western countries, improved on it with originality and creativity, and brought in several reform programs furthering economic growth and industrial development. The Lake Biwa Canal is one such project.

The first modern project is the Lake Biwa Canal project (8.7 km, 15.35 m^3/s, completed in 1890), which uses the water from Lake Biwa. In 1912, a second canal (7.4 km, 15.35 m^3/s) was constructed, contributing to the further growth of Kyoto. Starting at Ōtsu, both the canals take water from Lake Biwa (elevation: approx. 84 m) and reach the Kamo River (elevation: approx. 41 m) in Kyoto through the Yamashina and Keage regions. Other than the two canals, there is a branch (8.4 km, completed in 1890) that separates northward at the Keage region, passing through the temple Nanzenji and the Shimogamo region, and finally joining a stream of the Kamo River.

There are six tunnels in the first canal section. Among them, the first tunnel near the intake point extends 2,436 m, which was a distance that Japan had never experienced to tunnel before that time. To deal with it, besides taking the strategy of tunneling from both ends at the same time, the shaft excavation method (to dig a vertical shaft above the tunnel and then extend it horizontally in both upstream and downstream directions) was applied for the first time in Japan to shorten the construction period. The incline system (length: 640 m, width: 22 m, gradient: 1/15), which is a rail-paved slope that transports ships on a truck, was adopted to overcome a large vertical interval between the wharf of Keage and the wharf in front of Nanzenji. Hydroelectric power (described later in detail) from the canal was the main power source.

Kyoto experienced a sudden decline after the Emperor’s move from Kyoto to Tokyo in 1869. The population in 1881 was 236,000, nearly half of what it had been in the late Edo period. That year the governor of

Lake Biwa Canal and Keage Incline (Japan). This Kyoto canal is a representative example of infrastructure investment in the Meiji period (photo by Japan Society of Civil Engineers Library).

Lake Biwa Canal: aqueduct in Nanzenji (Japan). A branch of the canal passes through Nanzenji (photo by Japan Society of Civil Engineers Library).

Kyoto Prefecture, Kunimichi Kitagaki (1836–1916), was convinced that a canal between Biwa and Kyoto would offer transportation and water power for modernizing the industries. This canal would also solve irrigation problems, and the water supply would thereby revitalize the entire region.

However, the construction could only begin after Kyoto Prefecture prepared the proposal based on a preliminary inspection of the Asaka Canal in 1883. The inspection process necessitated a field survey by the Home Ministry under the supervision of Johannis de Rijke. They came up with a revised plan and modified design, tweaking compromises between Shiga and Osaka Prefectures. Shiga Prefecture detested water withdrawal and Osaka Prefecture worried about an increase in drainage. By then, it was already 4 years since the appointment of Kitagaki. In June 1885, Sakuro Tanabe (1861–1944) was appointed as the chief engineer for this project. He had just graduated from the Imperial College of Engineering (now Department of Engineering, University of Tokyo) in 1883. Tanabe, a genius with mathematical talent, had already unveiled his strategy for Lake Biwa Canal in his thesis. It is estimated that approximately 14,000,000 bricks and 3,000,000 m^3 of timber were used during the construction of the first canal with a workforce totaling 4,000,000 over the course of the build.

Plans for the canal underwent several modifications. The most significant upgrade was the introduction of hydroelectric power generation instead of power from waterwheels. In 1888, after construction began, Tanabe learned of the success of the world's first hydroelectric power generation plant in Aspen, Colorado. During his trip to the United States (US), he was very much convinced about adding hydroelectric function to the project. Construction of the hydroelectric power generation plant began in 1890. Completed by May 1891, it became the first hydroelectric power plant (as well as the second in world) for commercial purposes in Japan. Using hydroelectric power, Kyoto developed several industries in textile, wrought copper, machinery, and cigarettes. Moreover, the first electric train in Japan became operational between Kyoto and Fushimi (7 km) in 1895.

The total cost of this project reached ¥1,250,000 (equivalent to ¥1 trillion in current value). This was more than ten times the annual budget of the city at that time. The fiscal resources included communal industrial funds (subsidies from the Meiji government), national and prefectural subsidies, and public bonds of the city, as well as revenues from a special-purpose tax collected from all citizens. The Lake Biwa Canal brings revenue from the canal businesses and the hydropower industry as well as the electric power business. In fact, the profits from the electric power sector cover 80% of total revenue. In this manner, this project became profitable in 1898, eight years after its completion.

The Lake Biwa Canal is truly a comprehensive development project offering a host of benefits. It (i) provides passage to ships from the Osaka Bay to Lake Biwa through Yodo River via Kyoto, (ii) irrigates the Kyoto Basin, (iii) shifted milling rice from stamping to the use of waterwheels in Kyoto, (iv) provides water to Kyoto City, (v) provides drinking water for people, (vi) improves sanitation by providing flowing water to streams of the city, and (vii) develops industries and provides power for city trams. The citizens of Kyoto continue to enjoy abundant water from Lake Biwa carried by this canal. The part of the canal branching at Keage is aptly known as the Philosopher's Walk. This pleasant corridor has ample space for relaxation and is pleasing to the eye.

1.3.5 Modern Water Supply System and Tokyo

Rapid growth in population with urbanization brought new challenges and put a strain on water for domestic consumption. Ground water was insufficient and drawing water from lower reaches of rivers had sanitary concerns. Therefore, it became necessary to use the upper reaches of rivers and springs for supply to cities.

In early 17th century Japan, the city of Edo was equipped with comprehensive water supply systems that did not exist in Europe. In 1654, the construction of the 43-km-long Tamagawa aqueduct began from Hamura to Yotsuya, Tokyo. Although the difference in elevation between Hamura and Yotsuya was only 100 m, a channel was dug between them and it became possible to supply clean drinking water to the city through wooden gutters. The Tamagawa Water Supply System became the foundation of prosperity for Edo, causing the population to steadily rise to 1 million.

London suffered serious water shortages too in the early 1600s, and a solution to the problem came from a spring in Hertfordshire, 30 km north of London. Literally named New River Head, a new river channel was excavated toward a hill in the suburbs of London to flow down a 5-m elevation gap. Water was then distributed across approximately 30 km within the city through wooden pipes.

The greatest change came in the 19th century when sand filtration technology for water purification began. Initially, impurities in water were removed by filtration. But once it became common knowledge that water filtration greatly reduced diseases of the digestive system, water purification by filtration became widespread across the world after the mid-19th century.

The challenge of drawing, transporting, and distributing water by overcoming forces of friction and gravity was met by the introduction of pumps. These became the building blocks of the modern water supply system.

Japan's first modern water supply system started with filtration and pressurized distribution early in Yokohama in 1887. Water supply services were constructed in treaty ports of Hakodate and Nagasaki; from the major port cities, the current tradition of water supply spread nationwide.

The modern water supply system of Tokyo can be traced back to 1898. Water from the Tamagawa Water Supply System was allowed to settle by gravity, then treated by filtration at Yodobashi Purification Plant. After pressurization, it was distributed to the city through underground pipelines.

As the population of Tokyo increased, reservoirs were built in Murayama and Sakai in the early 20th century. The Ogouchi Dam reservoir and Higashi-Murayama Purification Plant came about in the mid-20th century to increase supply. However, the needs of the increasing number of households could not be met solely by the Tama River and its tributaries. Therefore in 1964, the year of the first Tokyo Olympics, several water purification plants were constructed near Kanamachi and Misato to tackle the water shortage. Water was also tapped from the Tone River System. Water treatment plants use a combination of flocculation, sedimentation, filtration, and disinfection techniques. After water is pressurized through pressure tanks, it is delivered to customers for daily use and industrial purposes. Today, together with some of the reservoirs of the Tone River System, the water supply of Tokyo is one of the world's largest, with a capacity of approximately 7,000,000 m^3/day.

1.3.6 Modern Sewerage System and Its Development in Japan

Interestingly, Paris, the capital of France, was in a squalid state at the beginning of the 19th century. Gutters meant for rainwater were overflowing with wastewater in the middle of streets; garbage and toxic wastes were found in huge piles at street corners. In 1845, a huge enclosed excrement disposal plant was constructed in La Villette, a suburb northeast of Paris, and domestic wastewater was transported to the plant by carriages. Simultaneously, large sewer pipes (diameters large enough to accommodate a person such that one could easily navigate the entirety of Paris via the sewer system) were laid underground covering considerable distances. It is common knowledge that the sewer pipes Jean Valjean ran through in Les Misérables are modeled after these.

In 1848 after the revolution, Napoleon III came into power and established the Second Empire in 1852. Baron Haussmann was given the responsibility of transformation and modernization of Paris. His aim was to construct an extensive sewer pipe network comparable to that of the Roman Empire. Tasked by Haussmann, engineer Eugène Belgrand (1810–1878) created an innovative network of underground pipes to prevent flooding. The newly constructed sewer system discharged the sewage of the entire city by gravity into the Seine—20 km downstream from downtown. The sewage was then processed in a centralized treatment facility (away from densely populated areas, further downstream), using the activated sludge process. This technology was developed in the United Kingdom (UK) and US around the beginning of the 20th century, and implemented in 1914.

Historic literature suggests Japan's unique approach to management of excrement. Throughout Japan's early modern period, farmers living on the urban fringe purchased human waste for use as agricultural fertilizers. Since city sewage was processed naturally on farmlands, there was no need to create large facilities for disposal unlike European cities. However, with increasing urbanization during the Meiji period, cities underwent rapid expansion. The first sanitary sewer system was built in Kanda, Tokyo in 1885 under the guidance of a Dutch engineer to combat the cholera epidemic that occurred in 1877. From 1930, the activated sludge process was adopted and became operational in Nagoya. In 1992, the Mikawashima Sewage Treatment Plant started operating using the trickling filter method prevalent in the US at that time. In this method, settled sewage is sprayed over a bed surface approximately 2 m deep and gets purified as it trickles downward coming in contact with layers of microorganisms attached to the solid media.

The modern sewerage system consists of two facilities. First, the sewer pipe facility progressively flows into larger pipes until the sewage reaches the wastewater treatment plant. Usually this is gravity powered; where gravity flow is not possible, pump stations are used

Tonan Purification Center (Japan). This center processes sewage in Morioka City (photo by Iwate Prefectural Sewerage Public Corporation).

to pressurize. The second part is the wastewater treatment plant. For purposes of gravity, these are located in low-lying areas. The first stage involves sedimentation—solids settle out, bacteria and organic matter are removed. In the next stage, 90% of all solids and organic material are removed by micro-organisms. Bacteria consume everything they can. Hence the activated sludge process using oxygen is the most prevalent choice in the modern sewerage system. Following this, treated water is disinfected chemically if needed.

Although initially rainwater and wastewater shared the same pipes, a different collection system was adopted for storm water and wastewater in large cities like Tokyo. However, with catastrophic damage during World War II, improvements in public health and coverage were still very low in the 1960s. Municipalities had to tackle the problem of excreta disposal. In the beginning, sewage was discharged into the sea. Eventually, the first Five-Year Program for Sewerage Construction was launched in 1963. Governments also subsidized municipalities in many ways to promote projects for the construction of sewerage systems and waste management facilities.

Box 1.3: Public Lavatories as Infrastructure

In urban society, public lavatories are a necessity, not a luxury. They need to be valued and maintained as any other infrastructure. Therefore, public entities are obliged to construct and maintain toilets as infrastructure investments—as important as bridges and airports despite the cost.

Public lavatories existed in Rome nearly 2,000 years ago at the time of the Roman Empire. Emperor Vespasian (*Titus Flavius Vespasianus*, reign: AD 69–79) invested in public works such as construction of the Colosseum and catacombs. He is known to have installed the first pay public lavatory in Rome in AD 74. In Italian, *vespasiano* still means "public lavatory in the city."

Modern-day European cities began to install public toilets—both for a fee and free—in parks and public spaces such as railway stations. Today, Japan, compared to other developed nations, stands out in public lavatory service both in terms of installation density and maintenance quality. In addition, public lavatories in Japan are mostly free of charge regardless of whether the public or private sector manages them, while in Western countries they are usually fee based.

Remains of a public toilet in ancient Rome (Italy) (photo by Yoshiaki Shirasaki / JTB Photo).

Take the example of Morioka, a local center city in the Tōhoku region. Morioka began constructing a combined sewer system for an expected population of 30,000 in 1958. In the late 1960s, they additionally constructed a terminal disposal plant and expanded treatment areas. The sewerage system finally covered not only city areas, but the entire basin including peripheral municipalities. The current population stands at about 260,000; the sewerage coverage is over 85%. Also early on, keeping in mind environmental concerns, the design of the sewer system was improved to discharge rainwater and wastewater in separate pipelines allowing only treated water to be discharged into the Kitakami River System.

1.3.7 Construction of Long and Massive Steel Bridges

In an age of rapid transportation, bridges are vital for crossing obstacles such as valleys, rivers, and even straits. They allow for the movement of people and transport of goods in large quantities within a short time. Timber-made girder bridges, stone-stacked arch bridges, and cable-supported suspension bridges are perfect examples of bridges meant for short distances. Constructing bridges for long distances was challenging as it required massive amounts of steel and iron. The expansion of railroads brought bridges with complex designs that could withstand greater weights. This gave birth to a whole new discipline of structural mechanics and technologies in construction methods.

The first impressive bridge totally made of cast iron was erected across Severn Gorge in Shropshire, England. This 100-ft bridge, literally named the Iron Bridge, had its humble beginning in a village, home to smelting iron with coal in the Coalbrookdale region of the UK in 1779. Having spurred the growth and expansion of the region, this new material completely replaced conventional stone material. Although it covered only a short distance, it set the foundation for the coming centuries of bridge construction—from simple stone structures to the massive, long suspension bridges of recent years.

New systems develop when the distances to be crossed exceed the capacity of existing systems. The box girder type evolved with the center hollowed out. The earliest example of this type is the Britannia Bridge (142 m, built in 1850 in the UK). However, in inland areas of Europe like Germany, where obtaining high-quality iron and steel was difficult, the truss type was easier to build, especially for railway bridges. This is because the truss type is lighter in weight and consumes less steel. Later, as structural mechanics and construction techniques evolved, constructing long, massive truss-type bridges like Forth Bridge (521 m, built in 1890 in Scotland) became possible.

Alexandre Gustave Eiffel (1832–1923) designed the Garabit Viaduct (175 m, built in 1884 in France), a huge wrought iron arch, in record time with minimal material serving as a single railroad track. This is one of the earliest examples of a truss-type arch. This lightweight but strong and rigid model gained popularity in European countries and the US.

The Menai Suspension Bridge (417 m long, with a maximum span of 176 m, built in 1826 in the UK) in Wales, is a suspension bridge supported by cables made of iron chains. Designed by the first chairman of the Institution of Civil Engineers, Thomas Telford (1757–1834), the bridge was opened in 1826.

Another splendid suspension bridge, the Elizabeth Bridge (290 m) was opened in 1903 in Hungary. Stretching over the Danube in Budapest, the complete length of the bridge structure amounted to 378.6 m, and the driveway was 11.0 m wide with pavements 3.5 m each. For 23 years until 1926, it was the longest suspension bridge. After the bombing during World War II in 1945 it was rebuilt at the same site with cables in 1964. Another chain-supported suspension bridge built in 1849, the Széchenyi Chain Bridge still stands north of the Elizabeth Bridge.

As manufacturing of steel cables became prevalent, suspension bridges became popular. An early example of this type of bridge was built over the Saane (Sarine) Valley in Switzerland (271 m) in 1834. Using wire technology, it showcased that when steel is drawn into wires, its strength increases. As the US invested more into research on suspension

Akashi-Kaikyō Bridge (Japan). This is one example of long bridges that consider aesthetics (photo by Honshū–Shikoku Bridge Expressway Company Limited).

bridges, major progress came with the understanding that the deflection of a suspension bridge caused by loads increases the stability of the entire bridge. The famous Brooklyn Bridge (486 m, built in 1883), the George Washington Bridge (1,067 m, built in 1931), and the Golden Gate Bridge (1,280 m, built in 1937) serve as outstanding examples of suspension bridges. One of the most famous bridge failures in the US occurred in 1940 with the collapse of the Tacoma Bridge in Washington. It was the third longest suspension bridge in the world at that time. The design allowed winds to exert strong forces on the structure rendering it vulnerable to vibrations caused by strong winds. This accident prompted dynamic and aerodynamic research of suspension bridges. The study of scale models in wind tunnels contributed to improving design. Supported by research, the design of bridges in recent years accommodates many factors: geology of the site, depth and nature of water, Earth's curvature, meteorological conditions, and other environmental characteristics. Thus, long, massive bridges with innovative design and function were constructed all over the world, keeping aesthetics in view. Noteworthy examples are the Humber Bridge (1,410 m, built in 1979 in the UK), the Great Belt East Bridge (1,624 m, built in 1998 in Denmark), and the Akashi Kaikyō Bridge (1,991 m, built in 1998 in Japan).

In 1955, the Strömsund Bridge was built in Sweden. This bridge adopted a new style of suspending girders by cable from its main tower. The Severin Bridge (260 m, built in 1961 in Germany) followed the same style. Built across the Rhine at Cologne after World War II, this was the first asymmetrical cable-stayed bridge with only one A-frame pylon,

Millau Viaduct (France). This bridge is another example of aesthetics and function combined (photo by Shigeo Hatsushiba).

positioned to one side. Due to the asymmetry of the system, the deck carried a significant compressive force. These cable-stayed bridges came to be widely constructed in Germany and then became the preferred system worldwide. Long, massive cable-stayed bridges were built, such as the Normandy Bridge over the Seine Estuary (856 m, built in 1995 in France) and the Tatara Bridge (890 m, built in 1999 in Japan) over the Seto Inland Sea. The Millau Viaduct built in 2004 in southern France is a 2,460 m bridge consisting of 7 consecutive cable-stayed bridges supported by piers as tall as the Eiffel Tower of Paris. Such an exhibit of excellent aesthetics contributed to creating a magnificent landscape.

Since long and massive bridges are for the public good, it is conventional thinking to charge a fee for using them, keeping in mind construction and operational costs. An increasing number of bridge construction projects with private finance initiatives (PFI), such as the build–operate–transfer (BOT) method, have been used to develop infrastructure worldwide. In this form of project financing, a private enterprise finances, designs, constructs, and operates the infrastructure for a certain period, enabling it to recover its investment. After a certain stipulated period, the project is returned to public institutions such as the government. The Millau Viaduct is a typical example of a BOT initiative.

1.4 Infrastructure of Everyday Life

1.4.1 Large-Scale Dams and Their Impact

Dams for specific purposes such as to control and stabilize water flow by closing rivers at narrow openings to form lakes or reservoirs have been the cornerstone of water resource management since ancient times. They serve to temporarily hold water as seasonal variations and climatic irregularities impede the efficient use of river runoff. Flooding or drought can cause huge problems, so dams ensure an adequate supply by storing during surplus and releasing during scarcity.

Furthermore, the hydraulic head of retained water is used to turn water turbines for generating hydroelectric power. To obtain a large head drop, massive dams have been constructed. Electricity generated from dams is the largest renewable source of energy today.

Dams with proper design, construction, and function have contributed significantly to fulfilling agricultural and domestic water supply requirements. In Japan, the Mannō Pond (32-m-dam height, Kagawa Prefecture), constructed early in the 8th century and improved upon by Kūkai (also known as Kōbō Daishi) in the 9th century, continues to serve communities.

During the 1920s and the Great Depression years, support for public ownership of utilities—especially hydroelectric power facilities—gained momentum in the US. This gave rise to the Public Utility Holding Company Act of 1935. Thus, the Tennessee Valley Authority (TVA) was born as the first hydropower agency.

The TVA was devised to modernize the region, combat human and economic problems, promote regional industries, and increase population and income, as well as improve social welfare in underdeveloped areas. The most dramatic change came from TVA generated electricity. Multiple dams came up in the basin of the rough Tennessee River to control flooding. This led to improved productivity and availability of arable land for irrigation. With hydroelectric power, industrial water promoted industrial expansion; stable domestic water revitalized communities. Construction of 32 multipurpose dams brought about a series of positive changes: industrial development, urban improvement, and medical welfare. This move encouraged grassroots movements leading to regional vitalization. The success of this project became a model example for many countries; in Japan, the Kitakami River Comprehensive Development Plan followed this model.

After World War II, the Aswan Dam, a 3,600-m-long, 111-m-high massive dam was constructed on the upper reaches of the Nile in Egypt. This helped in regulating the Nile's flow and preventing floods. It also provided Egypt with abundant hydroelectricity and water supply for irrigation projects. Although many benefitted and it promoted tourism, it was at a huge cost. People and historical artifacts were relocated amidst controversy. It had severe environmental impacts, creating an imbalance in the ecosystem.

During the 1950s to the 1980s, many countries including the former Soviet Union invested in dams for hydropower and irrigation. The Itaipu Dam on the Paraná River at the Brazil–Paraguay border is a massive group of dams capable of generating 14 million kW of electricity. Extending across 7.7 km, this complex of dams greatly helped Brazil counter its energy shortages.

The Three Gorges Dam of the People's Republic of China is one of the most ambitious massive dam engineering projects on the upper reaches of the Chang Jiang (Yangtze River) in Hubei Prefecture. This 185-m-high concrete gravity dam, with its output of 22.5 million kW hydroelectric capacity, is the largest in the world and contributed to the People's Republic of China's development boom. In addition to flood control, it improved water transport, enabling navigation of 10,000-ton-class ships toward Chongqing. However, the environmental impacts are profound. With several factories and mines submerged, massive industrial centers polluting the reservoir, and reservoir-induced seismicity threatening ecosystems, the dam has caused several problems. The sunken area at the bottom of the reservoir extends 660 km, endangering over 1.1 million residents living in its shadow.

After 1950, Japan constructed many dams to make efficient use of water resources and control floods. Most rivers in Japan are much smaller than those in other countries. Therefore, massive dams were not built. Nevertheless, reflecting the geographical features of Japan, many dams with smaller reservoir capacities were built, ensuring hydroelectric power generation, stable water supply, and irrigation. With controlled discharge into rivers, dams also have contributed to social stability through flood control. Tadami River in the Agano Basin is a good example that fully utilizes river water. Several step dams were built at heights of 1,425 m to Lake Ozenuma. Among these dams, the Okutadami Dam (height: 157 m) and the Tagokura Dam (height: 145 m) both had large reservoir and power capacities.

The Kurobe Dam (Kurobegawa No. 4 Hydro Power Plant) is an arch dam at the canyons of Kurobe River, which originates from the Northern Alps of Japan. There was a lot of difficulty in constructing it. The precipitous terrain posed tremendous hurdles, and it was important to safeguard the environment of the national park. The hydroelectric power capacity is capped at 335,000 kW—the highest in the country. In recent years, Japan has constructed mostly multipurpose dams, serving flood control, irrigation, water supply, hydroelectric power generation, and tourism.

Tagokura Dam (Japan). This dam in Fukushima Prefecture is one of Japan's relatively few dams having a large reservoir. Most are smaller due to Japan's geographical characteristics (photo by Electric Power Development Co., Ltd.).

1.4.2 Industrial Ports and Container Ports of Japan

Sea transport played an important role prior to the development of the modern means of land transport. Whether transoceanic or coastal, sea transport is more suitable for carrying bulky goods over long distances and has played a significant role in bringing different parts of the world closer.

In the 1950s, tankers and ore carriers were intended exclusively to ship oil and ore. Carriers have been steadily increasing in size to improve transport efficiency. Hence, older ports became too narrow and shallow for large ships. Meanwhile, factories of heavy industry such as ironworks and oil refineries expanded in size to increase productivity. To meet the increasing demand for transporting larger capacities of raw materials and manufactured goods, construction of larger ports at coastal industrial zones became essential.

Industrial ports handle raw materials and products for industrial use. New industrial ports are built along industrial sites. After the mid-1960s, many industrial ports were constructed in Japan. Their locations were chosen along coastal industrial zones with shelter from waves and sea currents, good logistic access, and proximity to areas with export and import demands. Although the conventional choice of location demands adequate depth, some of the ports of Japan are in shallow shores.

One such example is Kashima Port, constructed in 1965, approximately 80 km away from Tokyo. It is a completely artificial port; the total quay wall extends over 17 km. The sandy shore was dug into Y-shaped channels 300–600 m wide and 13–19 m deep, spanning a total length of 8,800 m. Two breakwaters (4 km and 700 m in total length) jut out into the rough Kashima open sea. These ensure safe navigation of ships sailing in and out of the port. Kashima Port boosted industries located along the quays as it could receive large specialized ships from

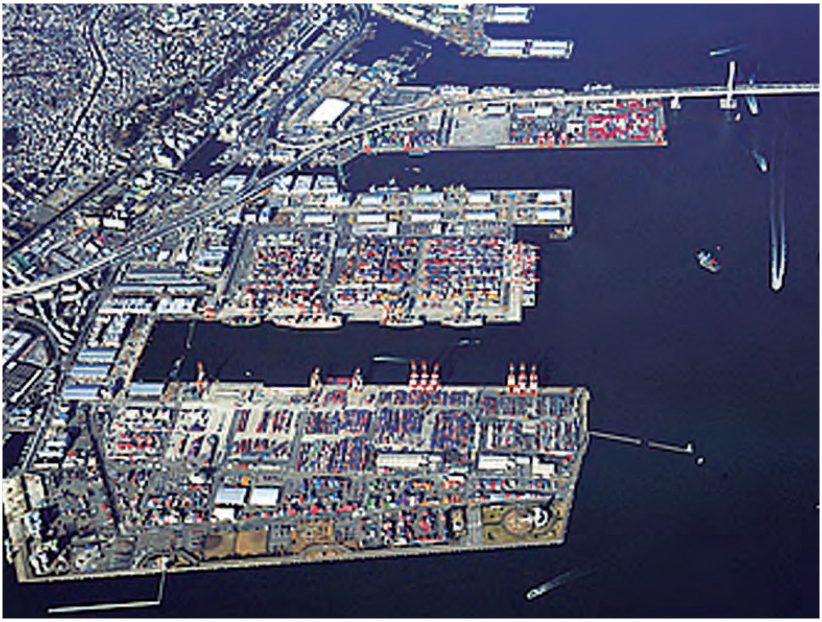
Kashima Port (Japan). Able to receive large specialized ships from far-flung locations, Kashima Port has grown to be an efficient seaside base in eastern Japan's Ibaraki Prefecture (photo by Kashima Port and Airport Construction Office, Ministry of Land, Infrastructure, Transport and Tourism, Japan).

remote regions such as South America and Australia. It enabled the import of raw materials at low cost while helping transport and export as well. As a result, oil refineries, steel factories, and power plants agglomerated around coastal areas. Kashima Port has grown into an efficient seaside base in east Japan.

The most influential invention in maritime transport is not just megaships but the shipping container. The impact of containerization has been enormous.

Any freight can be transported safely by sea and then put on trailers or trains to their destinations. In container transport, large gantry cranes installed at berths swiftly load and unload alongside quays. Container-packed freight from inland can be swiftly loaded on megaships at departure ports, transported by sea, promptly unloaded at the port of destination, then finally delivered by freight trailers to its final destination. In recent years, large container ships with load capacities of 18,000 twenty-foot equivalent units (TEU) have become operational and decreased maritime transport costs. However, due to their bulky sizes, they entail adaptations in infrastructure such as extensive berths (1 berth = 400 m length and 18 m depth).

In the 1970s, Kōbe Port (Hyōgo Prefecture, Japan) was constructed with state-of-the-art facilities and ranked 4th largest container capacity



Yokohama Port, Honmoku area (Japan). Yokohama Port became Japan's first top-class international trading port in the Meiji era (photo by Yokohama Port Corporation).

port in the world (1.46 million TEU as of 1980). Yokohama Port, since the Meiji times, served as Japan's first top-class international trading port. Port facilities and logistic facilities are clustered around the Daikoku and Honmoku Piers. Tokyo Port continuously handled imported freight in large numbers, went through upgrades, and new container terminals were constructed in Shinagawa and Aomi. In the 1980s, it was one of the top 20 largest ports in container capacity (Yokohama Port: 720,000 TEU, Tokyo Port: 630,000 TEU, as of 1980).

Since 2000, East Asian countries led by the People's Republic of China have seen comprehensive construction, growth, and development of ports. The technology and logistics of some Chinese ports are far advanced with impressive cargo handling facilities and container traffic facilities (Shanghai: 36,540,000 TEU, Shenzhen: 24,200,000 TEU, as of 2015).

With improved efficiency in ocean transport systems, container mega-ships carry cargo in the main arterial routes. The cargo is reshipped using smaller ships to large hub ports, then transported via feeder routes to regional ports. Under such circumstances, the container ports of Japan have significantly lost their position in the world (Tokyo: 4,630,000 TEU, Yokohama: 2,790,000 TEU, Kōbe: 2,710,000 TEU, as of 2015).

Cruise tourism is a recent trend, and each year, people are boarding large, luxurious passenger ships around the world. To keep up with the trend, Japan has started upgrading facilities such as wharfs to accommodate large passenger ships.

A port is a huge integrated system for handling cargo and passengers safely and effectively. These facilities include breakwaters as protective facilities, sea routes and anchorages for sailing and mooring vessels, quays for loading and unloading cargo, and a host of infrastructure for cargo storage and handling. Also, lighthouses and navigational aids are vital to the safety and survival of marine traffic.

Former Prime Minister of Singapore Lee Kuan Yew (1923–2015) declared that ports and airports are the most essential infrastructure systems for the social and economic development of island countries. To sustain a world-class level of economic and tourism activities, improvement and development of ports are imperative to Japan's future.

1.4.3 Appearance of Large Airports

Jet engines revolutionized air travel throughout the world. They spurred real growth as airlines were able to offer economical travel for passengers and products from distant places in shorter times. However, construction of new airports is difficult in urban areas because jetliners require more space for takeoff when compared to the conventional propeller aircrafts, and they produce more noise as well. Hence abundant land to accommodate long runaways away from residential areas is necessary.

New aviation infrastructure for commercial jets is constructed away from congested urban areas. This is possible for inland cities with extensive land such as in the US. But to find enough land in the vicinity of a metropolis is challenging for densely populated East Asian cities.

An airport is a mega facility consisting of runways, aircraft gates, aprons and taxi lanes, air traffic control facilities, and terminal facilities for passenger convenience and comfort. At least 200 hectares of land are needed to construct local airports; for large international airports, the requirement can go up to 10,000 hectares.

Fortunately for Singapore and Tokyo, airfields were constructed in the coastal areas at the time of propeller aircrafts. Following trends in mass transportation, new airports were constructed by extensively improving and expanding airfields to accommodate jetliners.

Singapore is a city-state on a small island at the tip of the Malay Peninsula. The only advantage this resource-deficient island has is its strategic location on the transportation route connecting Europe, India, Australia, and East Asia. The government of Singapore thoughtfully designated airports and ports as crucial infrastructure. It actively promoted land reclamation and expansion of air bases in coastal areas to construct the Singapore Changi Airport, which holds two parallel 4,000-m-long runways and became operational in 1981. As part of efforts to keep up, Singapore has been constantly improving and upgrading its terminal facilities and traffic access. This has vastly contributed to the remarkable development of the small island country.

The Itami Airport of Osaka lies within its metropolitan area, but because of its proximity to residential areas, there have been complaints of air and noise pollution. As the area around the airport became increasingly dense with economic growth, land was insufficient for expansion. So new runway plans were moved to another location.

The new airport plans began on an offshore location in 1987 in the Osaka Bay area, 5 km away from the shore. Consequently, Kansai International Airport (KIA) came into existence on an artificial island at a depth of 18–20 m. The first phase saw 3,500 m of runways completed in 7 years; in the second phase, 4,000-m-long runways were constructed in 13 years. By 2007, the airport was complete, totaling an area of 1,043 hectares. Kansai's islands were predicted to evenly settle as they have been built on reclaimed land. Although corrective measures are in place, it is hoped that the airport settles slowly and evenly at the calculated rate.

Dozens of airports have been built on land reclaimed from water in some East Asian metropolises. Hong Kong International Airport and Incheon International Airport in the Republic of Korea are examples. Although the depth of reclaimed land was not as deep as in the case of the Kansai International Airport, these airports were constructed alongside large-scale reclamation works. Besides housing huge terminal facilities,

Chek Lap Kok International Airport (Hong Kong, China). Dozens of airports have been built on reclaimed land (photo by Hong Kong International Airport).

Kansai International Airport (Japan). The depth of the reclaimed land for this airport is particularly deep (photo by Ministry of Land, Infrastructure and Transport Civil Aviation Bureau).

these airports are also equipped with high-speed rail and expressways to provide land access between airports and downtown areas of Hong Kong, China and Seoul, respectively. In addition, affiliated facilities such as hotels and convention centers were built around the periphery of airports, enabling ease of international operations.

In addition to airport and airfield civil engineering infrastructure, air traffic control facilities for safety such as tower control, landing aids, aerodrome lights, and aeronautical radio navigation systems form an integral part of air transport infrastructure.

1.4.4 Lifeline Supporting Civic Life

Power supply is an essential part of infrastructure, functioning as a lifeline for all societies. Most of it is installed underground in urban areas; part of it is laid overhead as power lines.

Electricity is undeniably the most utilized form of energy universally. Generated at power plants, it is transmitted to substations or load centers and then through the distribution system to consumers at home and industries. Large-scale power generation includes thermal plants that utilize oil and coal as fuel, nuclear plants that “burn” uranium, and hydroelectric plants that utilize the energy of water. Other categories of power plants convert geothermal energy, solar power, and wind power into electricity.

In Japan, thermal power plants are typically located on coastal areas because raw materials for operating them are imported. Nuclear power plants are positioned predominantly on distant shores with access to water for cooling, and away from residences. Large hydroelectric power plants are situated in remote mountainous valleys as they are dependent on the kinetic energy of water in lakes and reservoirs.

Since the source of electricity that consumers purchase varies, and the electricity is supplied from distant locations, long-distance power transmission is inevitable. High voltage transmission lines carry electricity over long distances through fields and mountains toward substations. Transformers at substations above or underground adjust the voltage before distribution to homes and businesses through conduits overhead or embedded underground.

The infrastructure for telecommunication networks has become indispensable to present-day life. Cable lines are laid between telephone exchanges and subscribers. Telecommunication cables are arranged as overhead wires on utility poles or fixed underground via conduits or utility tunnels. Metal conductors of the past have been replaced by optical fiber cables capable of high-performance data networking and telecommunication.

It has been a concern that overhead wiring of electric wires and telecommunication cables blemishes the beauty of streets especially in urban areas. Utility poles can be an obstruction at traffic junctions and are prone to collapse during earthquakes. Therefore, many cities are laying electric wires and telecommunication cables underground, aimed at avoiding overhead wiring and poles. In most industrialized countries, technical improvements in cable technology have advanced the reliability of underground power. Submarine communication cables laid on the sea bed between land-based stations across stretches of oceans and seas are vital infrastructure to the global economy.

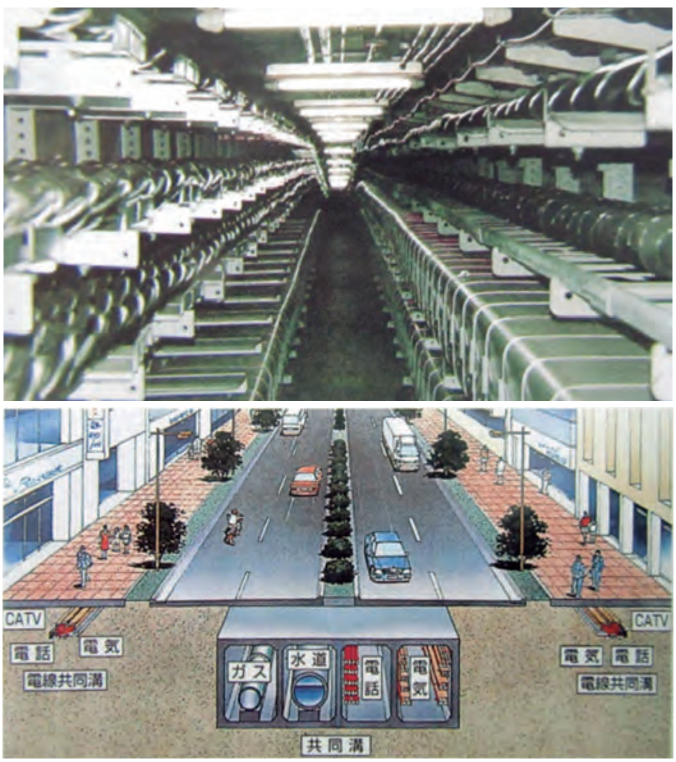
In recent years, mobile communication by way of cellular phones has evolved dramatically. This portable technology has overtaken conventional communication networks. Except for telecommunication towers for cellular base stations, other ground and underground communication infrastructure has been reduced considerably. Since the mobile phone is an accessible and integral part of interpersonal communication, developing countries can do without fully equipped conventional communication infrastructure.

In many cities, city gas operates gas pipelines to supply offices and households. As Japan is dependent on imports of liquefied natural gas (LNG) for city gas, pipeline networks are installed in areas where LNG terminals are built. City gas is produced, piped, and sold through these systems after refinement and calorific value adjustments to consumers via an underground supply system. In the cases of Tokyo Gas and Osaka Gas, where their outreach is extensive, the length of gas pipelines reaches nearly 60,000 km.

Sodegaura Liquefied Natural Gas Terminal. Liquefied natural gas is transported by sea at minus 162°C (photo by Tokyo Gas Co., Ltd.).

Wired overhead or buried underground, electric wires, telecommunication cables, and gas pipelines must be mounted individually. In recent years for efficient operation and maintenance of utilities, underground combined utility tunnels are the preferred choice. They are capable of hosting multiple services' infrastructure in safe, accessible spaces allowing easy maintenance and replacement. The evolution and enhanced performance of "undergrounding," especially from the viewpoint of aesthetics and to avoid recurring excavations for maintenance, has become the norm in developed countries (Figure 1.6). Still, the spread is limited to central areas of metropolises because cross sections of large common-use tunnels are comparable to subway tunnels, involving large initial investment costs.

Figure 1.6: Underground Power Lines in Urban Areas (Tokyo)



Construction image of common-use tunnel

Source: Ministry of Land, Infrastructure, Transport, and Tourism, Tokyo National Road Office.

1.4.5 Conservation of Land in Japan

Japan is an archipelago vulnerable to frequent typhoons, earthquakes, tsunami, volcanic eruptions, landslides, and much more. Persistent measures to protect facilities and conserve land are crucial in this kind of ecosystem.

Coastal topography is constantly changing as the land surface is impacted by marine processes—shorelines broken down by strong waves, beaches eroded by littoral drift, and sand supply depleted as rivers flow into the ocean. Each year there is a threat of losing 200–400 hectares of the area, comparable to the size of a medium-scale domestic airport. Therefore, to defend and conserve coasts, various measures have been undertaken.

Wave dissipating blocks such as Tetrapods are installed to protect dikes and revetments in many places. To combat littoral drift and erosion of sand beaches, offshore breakwaters parallel to shorelines are built, installing head land perpendicular or oblique to shorelines. Man-made structures such as sand bags and sand fences protect the coasts and slow down erosion. The success of these measures depends on the geographical and oceanographic features of coasts.

To protect land from high tides and tsunami, seawalls are customarily erected. For example, the coastal area of Tokyo is protected

Kaike Coast (Japan). Various measures are used to combat coastal erosion, like these wave-dissipating blocks in Tottori Prefecture (photo by Ministry of Land, Infrastructure and Transport Hino River Office).

Shin-Onagi river water gate (Japan). These gates are meant to delay flooding and buy time for evacuation in the event of a tsunami (photo by Tokyo Metropolitan Government, Bureau of Construction).

from high tides by a seawall that extends 32 km in length. Sluice gates are also installed in suitable locations in combination with seawalls where rivers or canals exist. In Tarō District of Miyako City (Iwate Prefecture), the seawall stands at 10 m above sea level. The reasoning behind this is that even if a tsunami is bigger than the seawall, the wall will delay flooding and buy time for evacuation. These structures are designed to protect people and land from frequent disasters that can occur every several years.

Like the coasts, land in mountain areas is never stable. Sabo dams (debris or check dams) at alluvial fans or upstream areas prevent the outflow of sediment toward lower reaches. For instance, the Yodo River Basin in Kizugawa City of Kyoto Prefecture is covered by surface soil made up of crumbly decomposed granite. Some sabo dams were constructed after the Meiji period to control sediment runoff. These dams together with forests have turned the hills into a stable, green satoyama.[4]

Several similar sabo dam projects were successfully carried out nationwide in Japan. Mount Tate Sabo upstream of Jōganji River and

---

4 Satoyama is a human- influenced natural environment comprised of farmlands (rice paddies), secondary forests, reservoirs and channels, per the Ministry of the Environment's Conserving Satoyama through Environment-Friendly Rice Production. http://www.biodic.go.jp/biodiversity/shiraberu/policy/pes/en/satotisatoyama/index.html.

Mount Fuji Sabo at the "Ōsawa failure" of Mount Fuji are two examples worthy of mention.

It was estimated that the Toyama Plains would get buried 1–2 m due to the severe sediment environment of the Tateyama Caldera. Riddled with steep mountains, frequent earthquakes, brittle geology, and unprecedented amounts of precipitation due to runoff from the volcano Mount Tate, it was a recipe for disaster. Installation of sabo dams inside and outside the caldera greatly improved the city area in Toyama, producing an excellent effect as a disaster preventing system. This sabo project is a showpiece for disaster mitigation; it is an ongoing work due to the inexhaustible amount of accumulated sediment.

The Ōsawa failure collapse on the western slope of Mount Fuji was one of the largest collapses in Japan. Debris from the collapse continues to flow out. Various sabo measures (sabo dams and revetments) have been extended to prevent damage due to sediment runoff in the lower reaches.

Besides preventing catastrophic sediment runoff in mountainous areas, it is also essential to avert landslides and slope collapse in urban areas and higher plains of villages. Slope protection by concrete walls and anchor bolts are some of the preventive measures adopted in many regions.

Stepped waterway of Ushibuse River (Japan). Stepped waterways like this one in Nagano Prefecture help to mitigate erosion (photo by Takeshi Yoneoka).

Box 1.4: Two-Stage Disaster Prevention

The accuracy of natural disaster predictions can vary despite scientific and technological advances. One cannot exactly predict how, when, and where a natural calamity can strike! Therefore, based on past records, disaster-prevention facilities specific for each region have been planned to mitigate damage and economic loss.

The last few years have witnessed strong earthquakes, tsunami, and floods outstripping those previously recorded. In the face of these dramatic disasters, the modern approach has shifted to preparedness with physical defenses alongside social preparedness such as evacuation to reduce damage.

This shift comes from reflections on the Great Hanshin Earthquake in 1995 that destroyed several structures constructed using modern technology such as elevated viaducts.

The concept is to design structures with the assumption of two stages. Level 1 aims to avoid almost any damage to a structure from seismic motions that presumably occur over one time within its service life. Level 2 presumes maximum seismic motion that may occur in the future, and prevents any fatal damage to human beings from the collapse of a structure even its function is lost.

After experiencing the serious damage caused by the huge tsunami in the Great East Japan Earthquake of 2011, the concept of two-stage prevention has also been adopted in tsunami disaster prevention; that is, for relatively frequent tsunami, Level 1 prevention provides physical protection with seawalls against tsunami of an estimated height, and Level 2 prevention establishes comprehensive social disaster prevention with resident evacuation at its core against unforeseeable huge tsunami of a large return period.

Global warming is a major concern because we are more likely to see natural disasters beyond projected scales. A socially and economically wise strategy would be to not only adopt physical measures as modern engineering has promoted, but also to establish comprehensive disaster prevention with such design and planning concepts.

1.5 Transition of Demand for Infrastructure

1.5.1 Social Demand for Infrastructure

In the earlier sections, we described fundamental aspects of infrastructure that have evolved over centuries, citing examples from various countries. New facilities under investigation are emerging in different regions across the world to tackle needs distinct to each region. Considering this, new types of infrastructure never seen before are likely to become the norm in the future. Although it is difficult to predict what new device or system will evolve, as the social environment changes and peripheral technology develops, newer facilities will adopt new ways of living with healthier lifestyles. Historical analysis of the emergence of infrastructure reveals how different nations went through different stages of transition depending on social needs and technological innovation.

Maslow's hierarchy of needs is a motivational theory in psychology depicting a five-tier model of human needs at different levels in the form of a pyramid. The higher needs come into focus only after the lower, basic needs are met. From the bottom of the hierarchy upwards, the needs are physiological, safety, belongingness, esteem, and self-actualization. The same theory relates to infrastructure. As societies evolve toward the higher tiers, improvements in infrastructure need to meet societal demands. In the succeeding sections, the emergence of infrastructure in Japan and other countries will be discussed.

1.5.2 Social Demands and Transition of Infrastructure Development

1.5.2.1 Infrastructure Essential to Maintaining Life

To sustain a certain quality of life that satisfies basic needs of food, clothing, and shelter, it is necessary to have essential infrastructure within communities. This translates to irrigation and corridors for

National Road in 1950s Japan. The post-war period of the 1960s saw a boom in road construction (photo from Nagoya Kōbe Expressway Reports).

Sameura Dam (Japan). This dam is called the "water jar" of Shikoku (photo by Japan Water Agency, Ikeda Integrated Operation and Maintenance Office).

an agrarian society; more developed societies need aqueducts, roads, and bridges for transporting goods, as well as canals and small ports. Rapid developments in infrastructure were based on the lifestyles of people and society-wide organizational changes leading to increases in productivity. Utility services such as waterworks and roads, electric power and railways, and other requirements were no longer a luxury but a necessity for an industrial metropolis.

In Japan since the Meiji period, the nation has been investing ceaselessly to modernize and invest in fundamental infrastructure. For example, traditionally, agriculture in the Asaka Basin suffered due to water shortages. To solve this, the Asaka Canal was dug, and water brought from Lake Inawashiro. Otaru Port was constructed to transport coal and minerals from Hokkaidō to needed areas in Honshu (the main island of Japan). Since 1870, many infrastructure projects came about to support production and consumption habits of people. Railways and roads built during that period aimed to meet community needs. In fact, the post-war period of the 1960s saw a boom in construction of copious roads, ports, industrial zones, dams, and housing estates in response to fundamental needs of the nation (previously expressed as the "civil minimum" in Japan—the minimum infrastructure for a modern civilized society]. Modern-day Japan has achieved these.

1.5.2.2 Infrastructure for Safety

The next essential aspect that follows is infrastructure for safety and security. In the past, ramparts and moats were erected to defend cities against foreign invasion. Infrastructure such as the Great Wall of China were built to seal off and protect the whole territory. Modern security infrastructure includes forts and naval ports used by various countries; military bases have evolved too as infrastructure for national defense and regional stability.

To begin with, a typical infrastructure for safety in a community would be safe traffic facilities. Innumerable and diverse, these can vary from simple underpasses and footbridges to complex modern signaling systems and massive efforts such as elevated railroad projects.

Strategies for disaster prevention to protect countries and regions from natural disasters have also been implemented to tackle local challenges. In European countries where natural disasters are less frequent, fire-prevention in urban areas, flood control for rivers, and seawall security in the coastal regions have been prioritized. Since Japan is subject to frequent natural disasters, the emphasis on disaster prevention infrastructure has a sense of emergency.

In Japan, historical examples such as the river improvement in Kai Province[5] by Shingen Takeda and the separation of the Kiso Three Rivers by the Tokugawa Shōgunate illustrate the unique ways of river improvement and levee construction of the past. Today with increasing urbanization and overcrowding conditions, disaster risk reduction and prevention is an indispensable part of infrastructure.

The framework for disaster management measures in Japan includes the construction of levees and dams for river improvement, sabo and other initiatives for preventing landslides, coastal improvement works for reducing erosion, seawalls and evacuation facilities for tsunami prevention, and urban redevelopment projects for earthquake mitigation and fire prevention. Although Japan has traditionally engaged in serious efforts for mitigating disasters, it has also experienced large-scale disasters.

Therefore, the current measures are still far from enough given that the nature and form of urbanization influences the risk of disasters. Despite repeated disasters, people turn a blind eye to risks. This is probably because disasters strike infrequently. Most people tend to think disasters cannot happen to them, and they become complacent over time. The tendency is to focus on immediate threats rather than distant ones, so implementation of prevention projects gets shelved.

---

[5] Yamanashi Prefecture today, contiguous to Tokyo Metropolis at its east border and Mt. Fuji located on its southern border.

Normal Time **During Flooding**

Ichinoseki Idle Pond (Japan). This infrastructure protects safety in the case flooding in Iwate Prefecture (photo by Ministry of Land, Infrastructure, and Transport, Iwate River and National Highway Office).

Japan needs to make more efforts to step up the above mentioned infrastructure projects for the welfare of future communities.

Moreover, it is mandatory that every structure in Japan be equipped with measures against earthquakes to mitigate damage caused by strong tremors and soil liquefaction. This is the major difference from the infrastructure of other places such as the EU and US because they are not as prone to frequent earthquakes.

1.5.2.3 Infrastructure for Efficiency

Every society wants to function efficiently. Extensive, efficient infrastructure reduces burdens on the community, raising competitiveness within and between regions.

Since ancient times, paved roads and bridges provided easy passage. Canals facilitated the transportation of goods. Water was made accessible from its source to reduce the burden of carrying water. The invention of water wheels at creeks made the milling of flour easy. After the Industrial Revolution, railroads greatly improved the transportation of people and products, overtaking carriages and ships as the preferred mode of transport. Large canals such as the Suez Canal were constructed too, promoting transport across borders. Hydroelectric power generation improved the efficiency of energy sources; it has been widely exploited for industry, transport, and household purposes. The automobile industry demanded better roads and highways capable of running high-speed vehicles. After the introduction of super-high-speed railways in Japan, other countries in Europe and East Asia followed suit, establishing the gold standard in transport efficiency. Jet engines brought about commercial aviation, boosting the development of large airports. The gradual shift from conventional break-bulk terminals to container terminals made the long-distance transport of passengers and goods efficient. All this has changed the way people live today.

Takebashi Junction of the Capital Expressway (Japan). Improved infrastructure here in Tokyo as well as throughout the country has contributed to improved efficiency in various industrial sectors (photo by Metropolitan Expressway Co., Ltd.).

The development of these infrastructure systems vastly improved the productivity and performance of every region, raising competitiveness between regions. The economic boom of Japan from the 1970s through the 1990s owes much to the improved efficiency in various industrial sectors due to infrastructure. East Asian countries that were lagging in modernizing their industries intensified efforts to develop their infrastructure. Their nexus of policies contributed to what is publicized as the "East Asian miracle" and enhanced their competitiveness in the global arena.

Interestingly, developed industrialized countries including Japan have reached a plateau in the area of new construction of such infrastructure. The focus has now shifted to improving efficiency by bringing about management reforms such as privatization.

1.5.2.4 Infrastructure for Environmental Improvement

Consumption patterns driven by current growth-based economics have resulted in stress on the ecosystem. Environmental degradation, global warming, water pollution, and flooding along with biodiversity loss are some of the negative impacts of the economics of infrastructure. This embodies a paradox of abundance. Ironically, these very infrastructure systems produced a demand for higher standards of living.

Genbei River artificial river park (Japan). The origin of the river is underground water from Mt. Fuji. People can enjoy pure river water and a rich green environment in the river or on the stepping stones. (photo by CTI Engineering Co., Ltd.).

A number of approaches aiming to manage and minimize the environmental footprints of infrastructure for economic growth are being recognized by various governments by working toward restoring "green infrastructure." These include the channelizing of artificial rivers into natural rivers, construction of biotopes, creation of natural beaches from artificially formed shores, and restoration of tidal flats. As part of a massive environmental cleanup, a unique project is making headlines in Germany. Over a period of time, generations of toxic coal mines are being transformed into beautiful mountain lakes. (This project is discussed in detail in Chapter 2, Section 2.)

Investing in green infrastructure projects not only makes economic sense but encourages healthy ecosystems. Focusing on improving the quality of the environment in which we live and work will foster a better quality of life. Therefore, the construction of healthy residences, sewage and waste treatment facilities, and leisure facilities such as parks is being actively promoted. Japan lags behind the West in this aspect, but it has been consciously developing such infrastructure since the 1970s. In the past 50 years, although the coverage of sewage systems and other municipal infrastructure in Japan is complete, in densely built-up districts of metropolitan areas the living environment is far from satisfactory. Many districts across the nation need urban redevelopment projects from the viewpoint of disaster prevention.

1.5.2.5 Infrastructure That Promotes Aesthetic Beauty

If urban spaces inspire and are aesthetically gratifying, they are not only pleasing to the eye, but also a matter of pride for residents. The physical environment of Paris, its elegant streets and bridges, and its architectural splendor, as well as the urban culture supported by this infrastructure, contribute to its civic pride. In Japan, attraction of islands along the Shimanami Kaidō[6] is fashioned out of the natural beauty of the Seto Inland Sea and bridges and roads that connect the islands. This aesthetic and visual appeal fosters a unique sense of identity and pride for the islanders. Obviously, any development that is aesthetically attractive is multifunctional—it fosters a sense of identity within the community, improves the image of the destination, promotes tourism, and immensely contributes to regional vitalization.

Yamashita Park was built by reclaiming the seashore of Yokohama with the city's rubble generated by the Great Kantō Earthquake of 1923. Today it nurtures a healthy landscape for citizens to relax, while offering the attraction of downtown Yokohama. The Minato Mirai 21 district, essentially a redevelopment project of the old port area, began in the 1980s. Presently, its landmark waterfront attraction forms the iconic skyline of Yokohama. Such a shipyard redevelopment project that transformed into a new city center is not unique to Yokohama. In recent years, much emphasis has been on similar projects globally.

These kinds of new attractions that draw visitors aim to achieve regional vitalization. Imaginative reuse, redesign, and repurposing of existing infrastructure can better serve communities.

This can be noticed in Salzburg, Austria. Imagine if cities such as Kyoto and Kamakura became car-free zones with underground parking lots at city entrances, and access within the city was by cycling, mass transit, or on foot! Such "pedestrian cities" like Kyoto and Kamakura would be more attractive and welcoming, showcasing history with cultural heritage and making citizens healthier and happier.

This vision is not limited to tourist cities such as Salzburg and Kyoto. Redesigning infrastructure such as streets, parks, traffic facilities, waterfronts, and industrial facilities where the nature, history, and culture of local communities can be carefully interweaved, bears the potential to attract visitors. Aesthetically appealing townscapes are also essential to attract locals. A townscape of utility poles installed in a

---

[6] The Shimanamami Kaidō links Onomichi in Hiroshima Prefecture with Imabari in Ehime Prefecture. It is a 60-kilometer-long highway exclusively for automobiles that links the islands of the Seto Inland Sea with nine individual bridges, per Shimanami Japan (http://www.go-shimanami.jp/global/english/).

Minato Mirai District, Yokohama City (Japan). This district is one example of a redevelopment project that added aesthetic value to the cityscape (photo by Waterfront Vitalization and Environment Research Foundation).

haphazard manner with electric wires hanging around cannot evoke a sense of pride nor attachment from its residents. Therefore, improving the landscape by investing in necessary infrastructure for fixing cables, wires, and pipes underground will promote connection between the local community and physical environment by visual stimulation.

1.5.3 Future Course of Development

As discussed earlier, infrastructure development is not progressing in a step-by-step manner. In many countries, infrastructure is not constructed with a single purpose, but is expected to respond to several demands simultaneously. What we have described so far indicates that the type of infrastructure constructed depends on the prevailing social, technological, and economic context of a country. In other words, we cannot rule out that basic infrastructure for sustaining basic quality of life will be developed in the future. On the contrary, we expect that such infrastructure would be newly constructed when necessary. Moreover, the demand for replacing dilapidated infrastructure is expected to increase.

In Japan, local citizens increasingly demand infrastructure to improve safety and quality of life for the coming years. In addition, there is a social demand for infrastructure to respond to the increasing severity and frequency of disasters. There is also an urgent need to revitalize regions that have been declining. It is also obvious that future infrastructure projects will put more emphasis on the operation, maintenance, renewal, and improvement of existing infrastructure instead of new construction as in the past.

The demand for infrastructure construction is greater in developing countries. In this regard, the economic and technological assistance offered by Japan will remain significant. We also expect more opportunities for Japanese infrastructure-related enterprises to participate in the renewal, improvement, and management of infrastructure in developed countries. We will discuss these in Chapter 7.

Bibliography

Section 1.2

Tracy, J. D. 2000. To Wall or Not to Wall: Evidence from Medieval Germany. In J. D. Tracy, ed. *City Walls: The Urban Enceinte in Global Perspective*. Cambridge: Cambridge University Press.

Van Schoubroeck, F. and H. Kool. 2010. The Remarkable History of Polder System in the Netherlands. Paper presented during the international consultation on Agricultural Heritage System of the 21st Century, hosted by the M S Swaminathan Research Foundation.

Section 1.3

Bagwell, P. S. and P. Lyth. 2006. *Transport in Britain: From Canal Lock to Gridlock*. London: Hambledon Continuum.

Bühler, D. 2004. Brückenbau im 20. *Jahrhundert: Gestaltung und Konstruktion*. Munich: Deutsche Verlags-Anstalt.

Chapter 2

Principles for Infrastructure Development

Singapore's raison d'être was its port.

— Lee Kuan Yew (1923–2015), former Prime Minister of Singapore.

2.1 Concept of Infrastructure Projects

Any infrastructure project starts from people becoming aware of needs or possibilities and beginning to take action. This initial idea is considered from many angles: the effects it may have, various conditions, and many other factors. Finally, the concept of the project takes shape. Such ideas and concepts may be based on public interests or private motives. They may be initiated by an individual, government, or other organization. Each project has its own purpose and target as well. In this chapter, we will show how an infrastructure project is formed, introducing some precedents.

2.1.1 Public Interests and Private Motives

As infrastructure is built for social benefit, the public sector injects public funds or intervenes politically as necessary. The social benefit, in other words the promotion of public welfare, means to increase wealth, safety, and happiness, or to make people comfortable. To propose a new idea of an infrastructure project is a noble task and many people want to be involved with planning the infrastructure project.

However, the motivation does not always come from this ideal spirit; rather, it may come from a desire for business profits. Many projects aim for higher earnings and contribute to the improvement of social welfare as a result of external effects (the influence of one economic activity on another economic entity without going through the market). Actually, most projects in capitalist societies are profit-oriented. Examples include the British turnpike projects in the 17th century and the American railway projects in the 19th century. In Japan, we can find good examples in private railway projects. Let's look at a project of the Hankyu Corporation that combined urban development with railway construction.

In 1907, Ichizō Kobayashi worked for the company that eventually became the Hankyu Corporation, a famous Osaka railway company named Minō Arima Electric Railway. Kobayashi built a new business model that coupled residential estate development with the railway extending in the Osaka Metropolitan Area.

At that time, in the Osaka Metropolitan Area, most private railway companies such as Hanshin Electric Railway and Keihan Electric Railway had only paid attention to building railways between big cities or inside the city. On the other hand, Kobayashi was going to extend a new line to the suburbs, which had a small population. It was a difficult task for Kobayashi to make the line profitable.

Hankyu Train at Its Inception. This project combined urban development with railway construction (photo taken from Hankyu Holdings, Hankyu Railway: "100 Years of Progress").

A former banker, he was keen to make the railway project profitable without any subsidy from public funds. Looking along the route repeatedly, he noticed plenty of suitable land for residential areas. At last, he suggested a new lifestyle: people could live in the suburbs and commute to the city for work. His plan, called the Kobayashi Ichizō Model or Hankyu Model, was to purchase land along the planned route on a large scale before building the railway, and to obtain increased land value (capital gains) caused by the total development of the owned area.

As he was also deeply conscious of culture such as literature and plays, he built many entertainment-related businesses such as the Takarazuka Revue Company (a famous all-female musical theater troupe), Hankyu Department Store, the Toho movie company, zoos, hot springs, a baseball stadium, and cinemas. All of this contributed to an increase in demand for railways and improved the living environment and cultural life in the Osaka area. This model was imitated by other railway companies like Tokyu Corporation in the Tokyo Metropolitan Area.

2.1.2 Initiator of the Project

Let us look at an example of a person who conceived a big, successful infrastructure project after being inspired abroad. Tokuji Hayakawa, an ordinary businessman, struggled to lead the large project of building

A Historic Train Line. Yard and steel column of Tokyo Metro Ginza Line and statue of Tokuji Hayakawa (founder of Tokyo Metro) (photo taken from *Doboku Sekō* [Civil Engineering Technology Magazine]. 2015. May 56[5]).

the Tokyo Metro Ginza Line, one of the main metro lines of present-day Tokyo.

He had already managed to recover several local railways that had been in trouble. When he inspected the subway in London during a tour of Europe and the United States (US) in 1914, he thought that this might be an advanced means to address Tokyo's traffic congestion. However, almost no one in the public or private sectors thought this was a good idea. The reasons were the huge amount of investment it would require, a sense that it wouldn't be profitable, and the technical difficulty of constructing subway tunnels in Tokyo's soft ground. Realizing that the only way to achieve the project was to manage it by himself as a private business, Hayakawa persuaded many influential people to raise funds and set up a company, gained the support of engineers who wanted to pursue a new business, and was finally able to start the project.

Facing many political, financial, and technological difficulties and unexpected accidents such as the Great Kantō Earthquake of 1923, he finally completed the subway that is now called the Ginza Line between Asakusa and Ueno in 1927. Following that, he extended the subway line and enlarged the service area for passenger transportation. This line still functions as the most important high-speed railway in Tokyo, 90 years after it was built.

Many other infrastructure concepts were carried out by individuals. Let's take the example of the Shinano River's Ōkōzu Diversion Canal, which was implemented in 1931. The Ōkōzu Diversion Canal is in Niigata Prefecture and is about 60 kilometers (km) from the mouth of the Shinano River. It is an artificial waterway with a total length of about 10 km from Ōkōzu to the Teradomari Coast. When flooding happens, the water from the Shinano River is diverted through this waterway to the sea in order to protect the Echigo Plain, one of Japan's leading granaries, from flood damage.

The concept of the Ōkōzu Diversion Canal goes back to the Edo period (1603–1868). It started out with petitions for constructing a flood-control channel submitted twice in the middle part of the Edo era by Kazuemon Honmaya, who was a merchant of Teradomari. The Shinano River at that time was obstructed by Yahiko Mountain located along the coast and could not flow out to the sea a short distance away. Hence, it meandered through the Echigo Plain, causing frequent floods. As a result, many human lives were lost, and agriculture—especially rice cultivation—suffered great damage. Kazuemon Honmaya and those who followed in supporting the concept petitioned the Edo Shogunate many times regarding the necessity of a flood control channel, but it was never pursued because it was technically difficult and costly at that time.

In the Meiji era, the government finally decided to improve this area and the channel project began at last. However, the project was repeatedly interrupted, resumed, and cancelled. A big flood occurred in the middle of construction in 1896 and finally forced the Meiji government to rebuild a full-scale plan of the Ōkōzu Diversion Canal

Ōkōzu Diversion Canal of Shinano River. The project, started from one local merchant's idea, was repeatedly shelved and was completed 200 years later (photo by Shinanogawa Office of Ministry of Land, Infrastructure, and Transport).

beginning in 1909. Then in the year 1931, a quarter-century later, the flood-control channel was finally completed. Two hundred years had passed since the first initiative.

Owing to the completion of Ōkōzu Diversion Canal, the lower area of the Shinano River was spared from further flood damages. The levee of the river has never broken since. The paddy field of the Echigo Plain, once a wetland, has also changed to a well-drained dry field, and now it is one of Japan's leading rice fields represented by the famous rice brand of Koshihikari.

The concept that started from one local merchant's imagination for the public interest was implemented after a long time. This flood-control channel has not only improved safety and security for life by preventing flood damage but has also become infrastructure for high-valued agribusiness.

2.1.3 Promoter of the Project Concept

Today most projects are conceived by public institutions such as central or local governments. Some of these concepts are created by meetings including external experts that form a council. In this type of council, the project concept is discussed among various people who have different viewpoints, such as academic experts, influential people in the area (representatives of the chambers of commerce and industry, business people, residents' groups), and officials of central and local governments. However, to promote a project strongly, a powerful leader who can carry it out enthusiastically is needed. As an example, let us show you the case of Kashima Port.

Kashima Port in Ibaraki Prefecture is an important facility of the Kashima Coastal Industrial Zone, which has about 180 operating companies. This industrial zone is designated as a Special Area for Industrial Development in the Comprehensive National Development Plan by the Cabinet in 1962. But the idea was launched by Niro Iwakami, the governor of Ibaraki Prefecture at that time. Governor Iwakami believed that industrialization must revitalize the Kashima district, where development was delayed and people were suffering in poverty. In 1960, he invented the slogan, "Take Advantage of Both Agriculture and Industry," in which he planned to build a huge excavated port on the coast around which to attract factories, then to develop both industry and agriculture. He launched the Kashimanada Coastal Area Comprehensive Development Plan, in which Kashima Port was designated as the most important component of infrastructure.

Generally, the suitable land for a port was a quiet and deep inner bay. In the case of Kashimanada in the rough Pacific Ocean, it was a great

Kashima Port and Kashima Coastal Industrial Zone. This is an example of one individual (a governor) promoting a concept and pushing the idea to completion (photo by Kashima Port and Airport Construction Office of Ministry of Land, Infrastructure and Transport).

challenge to set up a large port harbor. On the other hand, it also had the big advantage of being located in the metropolitan area, with its large market in addition to wide land and abundant industrial water from the Tone River. Governor Iwakami proposed to build a large excavated port 600 meters (m) wide and to bring heavy chemical industries to this coastal area.

Although the scale was too big for a local government, Ibaraki Prefecture took the initiative on this project and acquired land in their own way. This method is called the Kashima Method. In acquiring land, they bought 40% of the land from the residents and acquired 60% of the land by exchanging it with other land for agricultural use outside the target areas of industrial development. Governor Iwakami also showed leadership in attracting companies to their industrial parks. He contacted VIPs in the political and business fields to seek their support, and finally set up heavy chemical industries such as steel, electric power, and petrochemicals.

Governor Iwakami repeatedly said, "This Kashima Port development is not our purpose but is just a means to rescue local farmers and fishermen from poverty." His efforts, coupled with the development of other related infrastructure such as expressways, led to the development of regional industry and job creation.

Next, we look at the story of a project in which an idealistic mayor delivered stunning results with innovative ideas.

The city of Osaka in the Taishō era (1912–1926) had been developed as a commercial and industrial city and had a population of more than two million. It was one of the largest cities in Japan along with Tokyo. However, urban development was delayed due to the lack of streets and other urban infrastructure. Most of its area was poor and dangerous with wooden houses crowded together chaotically. In 1914, Hajime Seki, who was a political economy professor at the Tokyo Higher Commercial School (now Hitotsubashi University), was appointed to Deputy Mayor of Osaka City by Mayor Ikegami. Ikegami and Seki rapidly set to work developing infrastructure including the water supply, parks, hospitals, and welfare-related facilities in this big city.

Seki became the mayor of Osaka as the successor of Ikegami in 1923. He undertook large-scale urban renovation projects that covered streets, bridges, the water supply and sewerage, harbor facilities, and subways as well as houses and schools. Among these facilities, the most revolutionary and representative project was the expansion of Midōsuji Boulevard and the construction of the subway.

Midōsuji Boulevard, built in the Edo period, was a street about 6 m wide and 1.3 km long from north Awajichō to south Nagahori. It was planned to be transformed into a large street bordered by ginkgo trees with a width of 44 m and a length of about 4 km from Umeda in front of Osaka Station to Namba, a populated town in the south. Moreover, a subway was planned under the street in order to connect the railway terminals between the north and the south. In addition to improving traffic in Osaka, Mayor Seki tried to improve the ability to prevent disasters and to create a more sophisticated landscape.

Surprisingly, this large project managed to be completed without compulsory land acquisition. Although it was promoted as an urban planning project, one-third of the project cost was paid for by the residents near the planning street based on a beneficiary payment scheme. The land that would face the new street was regarded as the first zone, and the land 45 to 63 m from the street was divided into the second, third, and fourth zones. For the first zone, ¥1,000 per 1.8 m of the frontage (about ¥4 million at the current monetary value) was imposed as a beneficiary charge. Besides, a charge of ¥3 to ¥41 per 3.3 m^2 was imposed on each zone. Sure enough, there was a big opposition against this heavy burden, but in the end the residents, expecting that this would aid in the development of Osaka in the future, agreed to it.

Today, Midōsuji Boulevard remains the main street and has become a symbol of the big city of Osaka. In 1935, the subway of the Midōsuji Line was completed between Umeda and Namba, two major railway terminals in Osaka. Thanks to Seki's idealism and the spirit of Osaka's citizens, the Midōsuji area remains the center of the city more than 80 years later.

Current state

At time of completion

Construction of Midōsuji Boulevard. Among the urban renovation projects of Osaka's Mayor Seki, this was the most revolutionary and representative project (photo by Osaka City).

2.1.4 Local Initiatives

The concepts of infrastructure projects can be roughly divided into two types. One is a "local initiative" that is initially planned in the local region and then incorporated into the plan of the central or local government. Another is a "central initiative" in which the central government designs projects necessary to the development of the whole country.

A project for improving the social welfare of the community is launched by individuals, community groups such as chambers of commerce, and municipalities in the region. In their meetings, they concretely show the difference of their locality's welfare level compared to other areas and insist that the project is necessary to raise the welfare of residents. In some cases, they claim government subsidies.

In the past, there were many successful cases in which local influential people raised funds with great efforts in order to improve poor transportation. For example, let us present the case of a small railroad in Ina Valley, now called the Japan Railway (JR) Iida Line.

The Iida Line, currently operated by JR Central, is a local railway 196 km in length connecting Toyohashi Station and Tatsuno Station. It was originally built as four individual private railways including Ina Electric Railway. As they threaded their way through the steep mountainous area, it took a long time to complete after being planned at the end of the Meiji era.

Every line was launched by local influential people. One of them, Ina Electric Railway, the first private railway in Nagano Prefecture, was encouraged to be built by the passion of people in Ina Valley, who once attempted but failed to initiate another railway project between Tokyo and Nagoya. The main means of transport at the time was railroads, so constructing railways was considered to be an essential condition for regional development. When the Central Line of Japanese National Railways from Kōfu to Nagoya passed through not Ina Valley but Kiso Valley because of costs and technical reasons, people worried that the development of Ina Valley would be delayed compared to that of Kiso Valley. People were also given the momentum to lay another railway in Ina Valley. Members of the Imperial Diet normally led campaigns for laying railway, but the residents of Ina Valley contributed their own funds and established the Ina Electric Railway Co., Ltd. (later the Ina Electric Railroad) to construct a railway. Starting from Tatsuno toward Ina, its section from Tatsuno to Ina Matsushima was first opened in 1909. It passed through Tenryū Gorge via Iida in 1927. More than thirty years had passed since they first proposed the idea. In addition, in order to connect to the Aichi Prefecture area, the railroad company was established in cooperation with the other two railway companies in Toyohashi and was extended to Aichi along the Tenryū River through Sakuma in Shizuoka. Finally, in 1933, the railroad leading to Toyohashi was fully connected.

During the construction period, they suffered from fund shortages and technical difficulties, but the stations opened one by one. We can find the remnants of those efforts today in the short spaces between stations: small curved radius, and numerous tunnels and bridges.

Shironishi–Mukaichiba

Tamoto Station

Iida Line. Originally four individual private railways, this line has contributed to the development of a mountainous and otherwise remote area (photo by Central Japan Railway Company).

The Iida Line contributed to the development of the mountainous areas by improving access to sightseeing spots such as Tenryū Gorge and Hōrai Gorge along the line, as well as a way of transporting materials for hydropower plants such as the Sakuma Dam.

2.1.5 Central Initiatives

For the development of the country, it is essential to both develop the overall economic power and mitigate regional disparities. Increasing economic power requires that the natural and social resources of each region are used effectively and efficiently. Mitigating regional disparities improves imbalances of regional welfare levels and helps to maintain social stability. For these purposes, infrastructure plays a very important role, so the central government should be concerned with the planning of its construction and maintenance. The infrastructure concept for the whole national area is made as a long-term vision mainly by the central government in consultation with councils consisting of experts and local public and private bodies. Let us next examine an example of such a long-term vision of road development.

Road development in Japan has been led systematically by the central government. Particularly after World War II, according to the Road Law established in 1952, various regulations concerned with roads such as maintenance procedures, management, and cost burdens were instituted for national highways, national roads, prefectural roads, and municipal roads. In addition, detailed plans have been carried out in the process of the Five-Year Road Development Plan, which has been formulated several times since 1954.

In the process, the Road Council (the current Social Infrastructure Council, Road Subcommittee) has played an important role. The Council, consisting of academics and experts, discussed the direction of road development in order to improve living standards and to develop the national economy, and they compiled the results in the form of reports and proposals. In response to these, the central government (Ministry of Land, Infrastructure, and Transport) set up concrete projects relating to road development in the form of the Five-Year Road Development Plan and promoted actual road improvement after the Cabinet decision. This method of formulating a long-term vision through the council discussion has been applied to other large-scale infrastructure projects such as ports, airports, and rivers in Japan. Although the department responsible for each component of infrastructure tends to devise overblown concepts and plans, the experts of the council make comments from multiple perspectives of industrial policies, social environment, and regional development. As a result, their plans are confirmed and revised.

On the other hand, the Comprehensive National Development Plans were put together using local ideas and then integrated the nationwide perspective. They were based on the National Land Comprehensive Development Law enacted in 1960. In addition to central initiative large-scale infrastructure such as *shinkansen* (high-speed rails) and highways, many concepts from regional initiatives are included in the plans. The Comprehensive National Development Plans stipulate the following matters.

- Use of natural resources such as land and water
- Disaster control against flood damage and wind damage
- Scale and arrangement of cities and rural areas
- Proper location of industry
- Scale control and allocation of important public facilities such as electric power, transportation, and communication
- Protection of resources on culture, welfare, and sightseeing and scale and allocation of facilities

Many local initiative concepts were incorporated into the plans and were authorized.

Actually, the history of the national development plan is short; we can only see the beginning of it in Japan before World War II, for example in the Guidelines for Land Use Planning (Cabinet decision) in 1940. It is after 1962, when the Comprehensive National Development Plan was set up, that the regional project concepts were regarded and authorized as national development plans.

Even in that short history, a few exceptional projects have been led by the central government. Let us review two cases in the Tōhoku region that the Meiji government executed as national projects.

After the Meiji Restoration, the new government tried to develop the Tōhoku region for promoting industry and selected the Asaka Development in Fukushima Prefecture as a model case. One of the most essential projects of the Asaka Development is the Asaka Canal project. It was a drainage system used for irrigation of the Kōriyama basin, which had poor agricultural production due to water shortages. The canal project directed the water of Lake Inawashiro, which until then had flowed only to the sea, through the Ōu Mountain Range and to the area facing the Pacific Ocean. It was completed in 1882 over three years and was regarded as the first publicly financed project by the Meiji government. After the completion of the Asaka Canal, it became possible to use the water resources of Lake Inawashiro for various purposes such as agricultural use, and the development of this area progressed. The success of the Asaka Development has greatly contributed to the modernization of not only Fukushima but the whole Tōhoku region.

Asaka Canal/16 Bridge Gate. This was the first project publicly financed by the Meiji government (photo by Yūichi Nakamura).

Nobiru Port in Sendai Bay was Japan's first Western-style harbor under the administration of the Meiji government. It was also regarded as an important piece of infrastructure for Tōhoku development by the Meiji government. This project was not only a port project but was one of the components of the water transportation network. The network consisted of canals and rivers as well as Nobiru Port and it enabled Tōhoku products to be transported to markets such as Tokyo. The project began in 1878 and opened four years later in 1882, only to fail when a typhoon hit two years later and fatally damaged the estuary jetties. Now, Ishii Lock Gate, a representative remnant of Nobiru Port, is preserved as an important cultural asset.

2.2 Motivation for the Planning

Why does infrastructure planning come about? Various projects launched by individuals or groups in local regions or the central government have their own reason to emerge. We will discuss them in several categories, although no projects are planned for just one reason. In reality, projects come about because of a combination of these categorized reasons.

2.2.1 Demand

In an economically growing society in which both production and consumption continue to increase, the supply of infrastructure always lags behind the growing demand. This may decrease social welfare. In Japan, the shortage of infrastructure was extremely severe in the 1950s, when the economy developed rapidly in spite of the massive infrastructure damage from World War II.

The Watkins investigation team, which was dispatched from the World Bank to Japan in the mid-1950s for a financial investigation to construct the highways, reported, "The roads of Japan are incredibly bad. No other industrial nation has so completely neglected its highway system." As this statement shows, the shortage of road infrastructure in Japan was extremely serious. The shortage was remarkable not only in roads but also in transportation infrastructure such as railroads and ports, and in energy and water supply infrastructure such as electric power and industrial water. As the standard of living improved, the gap between supply and demand tended to get worse not only in these industrial infrastructure areas but also in living infrastructure such as residential structures and water supply.

Since there was already high demand for the infrastructure, the necessity of developing the infrastructure was obvious to everyone. In this circumstance, what they urgently needed was not planning but to figure out how to efficiently supply and collect the necessary funds. In other words, considering the cost and effect of the project, we had to decide the priority order of projects with limited funds.

We could see a lot of infrastructure that was continuously developed according to demand, such as bypasses constructed along narrow old roads, rapidly expanded railway lines, port facilities, water supply facilities for daily life and industry, and power generating and telecommunication facilities.

Tōmei Expressway. Japan's infrastructure has come a long way since the 1950s (photo by Satoshi Ōsawa).

In Japan, owing to the whole nation's continuous efforts to develop fundamental infrastructure over the course of 50 years as stated in Section 1.5, the infrastructure supply finally caught up with demand and overcame the extreme shortage even in the circumstances of rapid motorization and urbanization after World War II. A similar shortage is still a remarkable problem in developing countries, preventing their social and economic development.

2.2.2 Safety Measures

National security is the most important mission of the government. Disaster prevention is a typical and important social service that the central government and the local governments should provide, especially in countries where natural disasters such as earthquakes, floods, volcanic disasters, and landslides occur frequently.

This requires highly technical knowledge and thorough research. In many cases, we do not know the exact time when disasters will happen, and most residents never think they may need to use disaster prevention services. In such a situation, the residents, who are the beneficiaries of this service, usually just request the service and are not involved in the concrete plan of the disaster prevention infrastructure.

Therefore, the administration must take the responsibility to judge the necessity of disaster prevention projects and proceed with the planning for construction of facilities. In short, the project planning of disaster prevention infrastructure should be devised only by administrations that can conduct regular investigations and special examination. Let us introduce the plan of the Arakawa Drainage Canal in Tokyo as an example of a large disaster prevention project that was planned by a government investigation and examination and was completed in the early 1930s.

The Arakawa Drainage Canal starts from the Iwabuchi Sluice Gate (Kita Ward, Tokyo), which separates the Arakawa Canal from the Sumida River. This artificial river drains floodwater into Tokyo Bay at the border of Kōtō Ward and Edogawa Ward of Tokyo. Before this drainage canal was completed, all water upstream flowed into the current Sumida River (the former Arakawa River). The Sumida River was too narrow for a large flow rate, so frequent flooding had occurred since the Edo era. The Edo town (which would eventually become Tokyo) often suffered great damage by flooding on the ground. In the Meiji era, as agricultural land came to be used for houses and factories, flood damage became more serious.

Flooding damage in 1907 and 1910 was especially bad. As result, the Ministry of Home Affairs, which controlled all domestic infrastructure

Drilling using manpower

Current state

Arakawa Drainage Canal. This is an example of a large disaster prevention project that was planned by a government investigation and examination (photo by Ministry of Land, Infrastructure and Transport).

at that time, began to plan the Arakawa Drainage Canal as a fundamental solution against flood damage. The Ministry of Home Affairs conducted a survey, and engineers in Japan at that time, such as Teisuke Harada and Akira Aoyama, participated in the planning and excavation. Aoyama was the only Japanese engineer who had been involved in the Panama Canal construction. He had also worked on the design and construction of the Iwabuchi Sluice Gate. The government acquired a vast area of land, and the Arakawa Drainage Canal, with a total length of about 22 km, was completed in 1930 after 17 years of construction difficulties. It greatly reduced flood damage in the river basin and greatly contributed to ensuring the safety of residents in Tokyo.

2.2.3 Economic Efficiency

Improving the efficiency of production takes priority over anything for international or regional competition. In many industries, economic loss from high costs and long transportation times occupy not a small proportion of the total cost. Therefore, especially in transportation infrastructure, construction of new facilities and updates are strongly required by companies and local regions in order to improve their economic efficiency.

Countries the world over have pursued improvements and the construction of port infrastructure, such as by exploiting sea routes for larger ships or building wharf facilities to improve the efficiency of cargo transport between land and sea. Let us introduce a good example: the Port Island in Kōbe, which was built at a time when container transportation was just being adopted.

It is not an exaggeration to say that modern economic globalization was caused by the containerization of marine transport. All kinds of goods such as foods, industrial parts, products, and miscellaneous goods are packed in containers and transported quickly and cheaply to final markets or intermediate demand areas all over the world. Parts produced in several countries are transported to other countries, assembled into finished goods, and sent to consumers around the world. Container transport has enabled these processes. Once packed in a container in an inland area, they are safely and rapidly carried by a container ship and loaded and unloaded quickly by the gantry crane on the wharf. They are then carried on railways and trucks and brought to their destination. In this way, container transportation allows us to save cost and time dramatically. It was a major innovation for cargo transportation.

For efficient container transportation, large sized infrastructure is required on the land. Kōbe Port, one of the biggest trading ports representing Japan, had only piers to handle cargo. It was too small to accept containers, which needed huge cranes and storage space behind.

In 1964, in anticipation of the high efficiency of container transportation and its development, Kōbe City set out a plan for a man-made island and container wharves. In response to this plan, in 1966, the Port Construction Bureau of the government and Kōbe City undertook the seawall and landfill construction of the island, constructing 9 deep-water container wharves with gantry cranes, 15 berths for general ocean freighters, and port facilities such as warehouse buildings. In addition, they built structures including apartment houses, office buildings, commercial facilities, schools, cultural facilities, and parks on the artificial island. In 1981, the first phase of construction was completed at last.

Owing to this island, the port of Kōbe was regarded to have the most modern facilities in the world in the 1980s. This contributed greatly to the efficient transportation of international trade in the Kansai area as the hub port of East Asia. Soon after, Port Island was expanded and a new island, Rokkō Island, was built beside it.

However, the Great Hanshin Earthquake in 1995 caused major damage to the cargo handling capacity of the port of Kōbe. Hence, Kōbe lost much of its competitive power as the international container hub port. The reasons of the decline are said to be not only the earthquake, but also an inefficient management system, such as breaks on holidays and at night, as well as complicated customs procedures.

Many industrial ports as well as container ports constructed in the 1960s were also planned for improving the efficiency of high-speed and mass transportation of raw materials or products of the heavy chemical industry located in the coastal area.

As the example of Kashima Port showed in Section 2.1, the improvement and development of transportation infrastructure are indispensable for not only marine transportation but also other transportation. Shinkansen and urban railways connecting workplaces to homes improved not only efficiency for passengers but also the operation of staff and vehicles in transport companies. Large thermal and nuclear power plants were also originally thought to increase the capacity of electricity production and as a result increase efficiency.

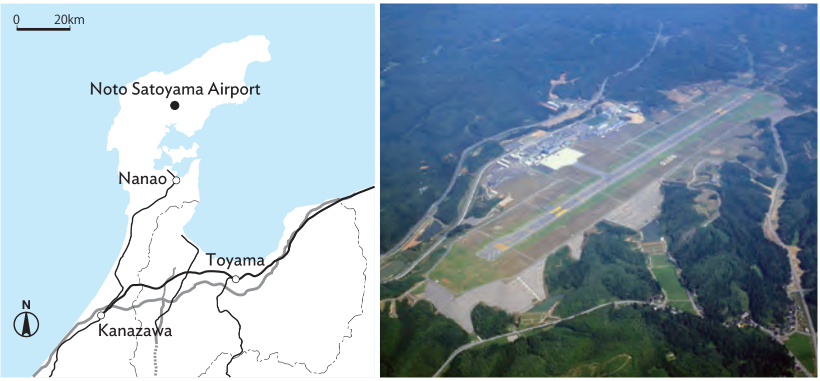
2.2.4 Regional Development Strategy

Since regions usually lose vitality with the outflow of their population, the decline of industry, and loss of employment, they seek to prevent these problems and look for ways to further vitalize their regions. Various solutions can be suggested.

Infrastructure projects for regional development once started with irrigation and cultivation in the field of agriculture. In modern times, railroads, roads, and ports attracted regional attention for inviting industries. Currently, since it has become difficult to draw factories, tourism is the focus for regional development by way of improving transportation and building-related facilities. As an example of this type of large-scale plan, let's have a look at Noto Satoyama Airport in Ishikawa Prefecture (Figure 2.1).

Wajima City and Anamizu Town are located at the tip of Noto Peninsula. This area is thought of as a poor transportation area. It takes three hours to get there by the express train from Kanazawa City, the capital of Ishikawa Prefecture. In 1986, the local prefecture

Figure 2.1: Noto Satoyama Airport



Source: Ishikawa Prefecture.

municipalities began a survey on the possibility of building Noto Airport in order to develop this area blessed with abundant nature but suffering from an outflow of its population. This plan was included in the Noto Regional Peninsula Development Plan supported by 220,000 signatures of residents, almost the entire population of this area. Under the great support of the local region, Noto Airport also came to be included in the Seventh Airport Development Five-Year Plan by the government in 1996.

In 2003, Noto Airport was finally opened with a total investment of ¥24 billion, with the support of the government's Airport Special Account (now called the Airport Development Account). In case that was not enough demand to enable regular flights of private airlines, the local municipalities suggested a boarding rate guarantee system. If the boarding rate was less than 70%, the prefecture compensated the airline for those lacking sales, while if the boarding rate exceeded 70%, the airline company paid cooperation deposits to the prefecture. This system finally enabled multiple flights between Tokyo and Ishikawa.

At the same time, in Noto Peninsula, attractions such as local nature and hot springs are used to attract tourists. In addition, an aviation school using airport facilities and a comprehensive administration center of the Oku Noto region in the terminal building were established. Through these actions, they tried to expand the airline demand and to increase the number of tourists and visitors in order to develop the remote peninsular areas.

However, not all regions can have such big infrastructure projects. Some regions can promote regional development by taking advantage of the construction of Shinkansen (bullet train) stations or highway interchanges. They can make plans to develop industrial parks and large commercial facilities and to improve infrastructure for tourism promotion, and so on. However, in many depopulated areas, it is rare to have such opportunities. Thinking of the recent depopulation and the aging society, no matter how small their scales are, it is desirable to create effective infrastructure plans for regional development under public–private cooperation in order to vitalize such areas where capital accumulation and human resources are insufficient, together with various soft solutions in welfare, culture, etc.

For example, let's introduce the Michi no Eki (roadside station) project that has seen about 1,100 points constructed all over Japan and has made an appealing effect on the vitalization of the region.

As the number of people traveling long distances by automobile has increased, drivers need a place to take a break on their way. In response to this demand, road administrators and local governments have set up service areas for drivers called Michi no Eki along the major roads

Michi no Eki. Hiwasa Michi no Eki in Minami Town, Tokushima Prefecture is one of about 1,100 such points serving travelers throughout Japan (photo by Ministry of Land, Infrastructure, Transport and Tourism).

since 1993. These roadside stations offer parking, toilets, telephones, and information available 24 hours a day. Most of them have been constructed by local governments, especially municipalities, as public facilities. In addition, cultural or tourism recreation facilities including shops of local products are operated to enhance regional development.

Because of these functions, most roadside stations are operated not by public but by private or semi-public third-sector companies. A few are operated by local governments and incorporated foundations. In recent years, stations that add functions of disaster prevention, such as stocking emergency food and water and securing emergency power supply, are increasing.

Although the road station is smaller infrastructure, it brings about not only the promotion of tourism and regional communication, but also more employment. On average, 60 staff members can be employed at each station, which is enough for small municipalities. The total number amounts to 70,000 employees in Japan. Compared with the employment of a large factory, counted to be at most a few thousand, the effect of Michi no Eki on the vitalization of rural municipalities suffering from depopulation should not be ignored.

2.2.5 National Strategy

Several aspects of infrastructure should be provided from the national perspectives of diplomacy, military affairs, economy, and research development.

For example, the assurance of the nation's safety is the first mission of the state and the duty for the government even if it is a "night-watchman state." From this viewpoint, infrastructure for defense, such as military ports and airfields, and maritime security activities, such as prevention and rescue of accidents at sea, are planned by the central government as part of the national strategy. Also, from the viewpoint of territorial protection, the wave-blocking blocks and concrete seawall in Okinotori Island are provided by the government.

The infrastructure planned as part of the national strategy is not only for national defense. In order to prepare for the possibility that petroleum imports stop due to a sudden change of international affairs, there are several large oil stockpiling bases established mainly by the central government in Japan. Let's have a look at the example of Kitakyūshū City, Fukuoka Prefecture.

When the 1973 Arab–Israeli War occurred, the Organization of Arab Petroleum Exporting Countries (OAPEC) significantly raised crude oil prices and laid an oil embargo against countries that supported Israel. Japan was heavily influenced by this action and suffered from a severe shortage of oil supply, causing a lack of daily necessities and inflation. In addition, the 1979 Iranian Revolution triggered the second oil crisis, causing a sharp rise in oil prices and extreme limitation of supply again. Japan, which relied heavily on imported oil for energy, tried to stock as much oil as possible inside the country to protect livelihoods and the economy from an unstable supply.

Shirashima Oil Storage (Kitakyūshū City, Fukuoka Prefecture). The petroleum stored here can provide 10 days of domestic consumption (photo by Hazama Ando Corporation).

Petroleum stockpiles were already held at private oil companies, but that was not enough. Therefore, the government implemented a national stockpiling project to build and operate oil stockpiling bases on its own. The national stockpiling bases were built at 10 domestic coastal points. Today, approximately 80 million kiloliters of petroleum are stocked in both national and private stockpiles. This can cover domestic petroleum demand for 197 days.

Although the stockpiling bases are extremely important for people's lives, they are usually opposed by local residents around them. Accordingly, they are built in remote areas or heavy industrial areas where oil tanks are built on land or offshore. One of them built in Shirashima, 8 km off the coast of Kitakyūshū City, consists of eight storage vessels surrounded by breakwaters. This is a large facility that stores 5.6 million kiloliters of petroleum, which can cover domestic consumption for 10 days. It was completed in 1996 together with port facilities like a sea berth for a tanker.

In addition, large-scale infrastructure is required for research and investigation of space, the ocean, and nuclear power nowadays. These huge laboratories, which can't be established by the private sector, are constructed and operated using government investment as a national policy based on the ideas of researchers.

2.2.6 Correction of Disparities

In Japan, there are many disadvantaged areas in terms of both the economy and daily life convenience, especially in snowy areas and islands. Generally, these areas cannot expect to succeed in various regional promotions. For stable national management, the central government should not neglect these areas exposed to depopulation and life difficulties.

One remarkable way to overcome these disadvantageous conditions is the construction of transportation infrastructure such as highways and bridges. In many depopulated areas, these transportation projects are not justified by their direct effects alone. However, the decline of these areas not only causes local devastation but also triggers overcrowding at the destinations of people moving away from the areas, which may cause various bigger city problems. In short, for the important purpose of national land management to achieve social stability by correcting disparities all over the country, we plan large-scale transportation projects.

People approve of the concept of a high-standard nationwide expressway network because its intent is to correct disparities. It also enables the central government to invest in numerous bridges to remote islands for local needs.

The New Comprehensive National Development Plan (Shinzensō) formulated in 1969 was a national plan originated in this viewpoint. Resolving regional disparities has been always been included in the subsequent Comprehensive National Development Plans made four times after the Shinzensō. All of these improvements of the nationwide transport network aimed to eliminate regional disparities, as these continue to be a big problem in Japan, where there are big differences in natural and social conditions between regions. It is clear that the development of various infrastructure, including transport infrastructure, can contribute to lessening these differences.

Here, we will discuss infrastructure projects to improve the disadvantages of remote areas in Japan.

Inconvenient transport areas, such as mountains and islands, have big handicaps in all areas of life, such as employment, education, culture, medical care, welfare, and consumption. They face serious regional problems like declining populations and loss of vitality. Tunnels going through the mountains and bridges crossing the sea are drastic measures to fundamentally change traffic conditions and to enhance social welfare in these remote areas.

On the other hand, it is difficult for small municipalities to invest in these infrastructure improvements. Therefore, based on the Remote Islands Development Act, the government subsidizes two-thirds of the project cost for cross-linking bridges to remote islands. In addition, the remaining payments are supported by local grants, alleviating the cost burden for the municipalities.

As an example of remote island bridges, consider the Wakamatsu Ōhashi Bridge on the Gotō Islands in Nagasaki Prefecture. This bridge with a length of 522 m was built between Wakamatsujima and Nakadōrijima in Wakamatsu Town (now Shinkamigotō Town) in 1991. It contributed to dramatically improving the convenience of island life and tourism conditions.

2.2.7 Improvement of the Living Environment

In recent decades, regional development by improving infrastructure has been advanced in various parts of Japan, especially urban areas, to improve the environment directly related to people's lives, such as housing, water sanitation, waste disposal facilities, and urban parks. Many of these had been in short supply behind the sharply rising demand coming from increasing urban residents and their higher living standards. Pushed by strong requests from those residents, administrative authorities have been promoting their action competing with neighboring municipalities. Thus, improvement of the living environment has been pursued as a project in response to demand in

Lake Cospudener (Leipzig, Germany). This lake is one example of a transformed living environment in response to requests from citizens (photo by Ken Akeo).

competition with other regions rather than a newly created plan. Here, we would like to introduce a project in which daring ideas were adopted to improve people's living environment.

In the outskirts of the city of Leipzig in Germany, there were once many open-pit lignite coal mines. After the German reunification, the German government reformed the energy policy of the former East Germany and stopped the use of brown coal, which caused a lot of environmental problems. As a result of this policy, there emerged many abandoned coal mines. The citizens and the Leipzig city authority wanted to rebuild this "negative heritage."

They removed contaminated materials from abandoned coal mines, filled the pit trails with water, created lakes, and developed the surrounding greenery. Now, there are several beautiful lakes including Lake Cospudener with an area of 4.4 square km and a maximum depth of 54 m. In the surroundings of the improved lakes, cafés and restaurants were built and people can enjoy various sports like boating, water skiing, surfing, and beach volleyball. The former lignite mining sites have been reborn as valuable recreation spaces with the efforts of the citizens and city of Leipzig. This new watershed will become 23 lakes connected by canals in a few years and a huge new lake district with a total area of 175 square km will surround Leipzig.

In Japan, an advanced plan for the urban environment has been created. It is the revival plan for the outer moat of Edo Castle in Tokyo, mainly organized by the authors of this book. It is a precious landscape where we can see the water in the outer moat of Edo Castle from the window of the Chūō Line (JR line) between Iidabashi and Yotsuya stations. Unfortunately, the surrounding area is crowded, the landscape is bad, and the water quality of the moat is poor. So, we plan to move the street running along this moat underground and to green the upper space as a promenade, redeveloping the surrounding buildings. We also plan to develop the gentle slope leading to the moat water and to create a shallow pool that stores purified water and a reservoir pool for when it floods. This water park plan aims to improve the living environment and landscape of the central city and to secure an evacuation space in case of a big earthquake. This plan is expected to be carried out soon.

2.2.8 Business Development

Business people with capital power, especially large companies, anticipate new demand and try to explore new business directions. There are many infrastructure projects run by private companies such as private railways, banks, real estate, and manufacturing industries to develop their new businesses. Granting that they have a capitalist motivation to increase corporate profits and value, we must acknowledge that they also expect their projects to raise the regional welfare level and have achieved this to some extent. The development of

Figure 2.2: Den-en-toshi Line and Tama Garden City

Tama Garden City by Tokyu Corporation (a private railroad company in the Tokyo Metropolitan Area) in southwestern Tokyo is a typical example of those achievements.

The Tama Garden City development began with a plan by Keita Gotō, chairman of Tokyu Corporation in 1953. This area on the hill of northeastern Kanagawa was once a military place during World War II and was a farmers' settlement after the war. The population was extremely sparse despite the close distance to Tokyo. Tokyu Corporation, which had already experienced urban development in the southwest Tokyo, laid a new railroad of 21.5 km in this area at first and then built a residential area using a land readjustment scheme around the station. The construction cost was covered by Tokyu Corporation and landowners provided part of the land as a reserved site just for Tokyu Corporation.

The railroad, called the Den-en-toshi Line, was opened between Mizonokuchi Station and Nagatsuda Station in 1966 and was extended to Chūō Rinkan in Yamato City in 1984 (Figure 2.2). Urban infrastructure including streets, water supply, and sewerage systems was developed throughout the area. Together with district development by the Japan Housing Authority (now Urban Renaissance Agency), a new city of over 5,000 hectares was built where approximately 500,000 people now live. Over the past 50 years, this residential city has been actively updated and improved in order to respond to living advances and aging of the population and to enhance urban living.

2.2.9 Update Improvement

Infrastructure that has been used for many years deteriorates. Meanwhile, social demands change regarding both quality and quantity as society and technology progress.

Most large-scale infrastructure projects that have been initiated in major cities in Japan or other developed countries are aimed to update the current infrastructure and expand its functions. Particularly in Japan, there is an additional focus on safety for disasters like large earthquakes.

The current projects to improve Tokyo Station, Shinjuku Station, and Shibuya Station and their surroundings are good examples in Tokyo. Regarding planning, the redevelopment of Nihonbashi and its surrounding areas is said to be representative of these kinds of large-scale plans. Let's look at the outline of the Nihonbashi plan.

Nihonbashi is a famous bridge of steel arches designed by Shinichi Yonemoto dating from 1911. Since the Edo era, the area around the bridge has been prosperous as a commercial town. It is located in central Tokyo. The road origin marker that shows the starting point of the whole road network of Japan is placed there. For the Tokyo Olympic Games in 1964, since urban highways had to be constructed in a short period with poor financial resources, an elevated road was built over the Nihonbashi River and the bridge. For over 50 years, this expressway has functioned as a major trunk line of the big city of Tokyo, but the huge amount of traffic day and night has caused aging and deterioration of this elevated road.

To improve this situation, a plan was made to rebuild the elevated road underground, which can improve the urban landscape in the Nihonbashi area. The plan aims to improve the environment and safety by purifying the Nihonbashi River and rebuilding the surrounding areas (Figure 2.3). Owing to support from public opinion, which comes from continuous efforts such as holding meetings with local residents and companies, the administration finally started to consider commercialization. Infrastructure upgrade refinement such as this example must be planned in many cities in Japan.

Figure 2.3: Nihonbashi

Current state **Nihonbashi Revival Plan**

Source: Tokyo Road Office of Ministry of Land, Infrastructure, Transport, and Tourism.

2.3 Advancement of Planning Concept

Those who wish to make an infrastructure project happen have to go through various processes. We will show what kinds of processes are necessary to advance the planned concept.

2.3.1 Public Relations

It is essential to obtain support from the public before stepping into implementing the planned project. In other words, getting public understanding is a prerequisite of implementation. Therefore, the contents of the project must be publicized to people in various ways. The approach to publicity activities must be well thought out so that everyone can easily understand the effects and contents of the project. For instance, a drawing of what the project will look like when completed is useful to enable people to visualize the final state of the project site (Figure 2.4), and a moving picture with computer graphics is perhaps even better.

Figure 2.4: Revival Plan for Outer Moat of Edo Castle

Source: Hidetoshi Kawaguchi.

It is also necessary to clearly explain the project's influence on society or the environment. If an unfavorable impact is predicted, the project promoters have to explain how to take measures against it in the early stages. It is necessary, for example, to express their measures and the expected effects using diagrams or other methods.

2.3.2 Dialogue and Assembly with Residents

It is important to have symposiums and citizens' meetings with experts where stakeholders including residents can understand deeply the contents and significance of a project. By using visual methods, their understanding will be more easily deepened. It is also important to make time to listen to criticism against the project and opinions on its modification.

In the case of the revival plan for the outer moat of Edo Castle mentioned in the previous section, the planners held seminars and model exhibitions of the projects in which residents, teachers, and students living in the surrounding area could participate. On such occasions, it is necessary to introduce similar advanced cases from other countries and regions, and moreover it is desirable that participants should be from diverse fields.

These sorts of meetings can be reported on by mass media such as regional newspapers and television. Additionally, making a website or other online presence contributes to making the relevant information accessible to more people. By means of this media, the project promoters should make efforts to spread and deepen public awareness of their project.

As an example of repeated dialogues with residents that contributed to a project's success, the Sōsei River rebuilding project in Sapporo is worthy of reference. The Sōsei River, which originates in the Toyohira River and heads toward the center of Sapporo, is a small river running perpendicular to Ōdōri Park while running parallel to a national highway in the city. This highway, named Sōsei River Street, consisted of two four-lane roads running on both sides of the Sōsei River and was crossing a big street at only two places in the form of an underpass. Also, the river area did not function as a beautiful natural space in the city.

Although the highway was three-dimensionally crossing at two places without intersections, there was still a need to reduce traffic congestion. Moreover, development of the waterside and green areas of the urban environment was required. Hence, the city officials came up with the idea of burying four lanes out of the total eight lanes under

Revival Plan of Sōsei River. The project took a thorough approach to citizen participation.

the ground to make the roads continuous over the entire sections. Their plan also attempted to develop green areas along the river by utilizing the above-ground space where the original roads were located. This plan was positioned as the Fourth Sapporo Long-Term Comprehensive Plan in 2000.

After the plan was launched, a citizen questionnaire was conducted immediately, and a citizen workshop was held as a study group. In 2004, Sapporo sought to build consensus on the project by setting up a social gathering consisting of surrounding residents, shopping mall merchants, citizen groups, academic experts, and the city. Also, they established a design committee with experts, who created many models and perspective figures through specialized examinations. Following discussions at numerous gatherings such as workshops with 1,000 people and citizen social gatherings, the plan was eventually approved as an urban planning project in 2005.

The project started in 2005 and finished in 2011 after the completion of the underground road, ground road, river construction, and green area construction. Now it alleviates traffic congestion, provides a green and fun space, and helps citizens to live more conveniently. Today, thanks to citizens' participation from the early stages, the citizens have more affection for the site.

Besides the above processes, if needed depending on the features of the project, it may also be an option to conduct social experiments both in order to verify the validity of the project as well as to deepen people's understanding.

2.3.3 Opposition Movement and Litigation

The process and time required for putting an idea of a project into practice vary depending on the project. In the early stages, projects often experience litigation with residents whether in Japan or elsewhere. Let us introduce two large-scale German projects as examples of projects that were realized through difficult situations.

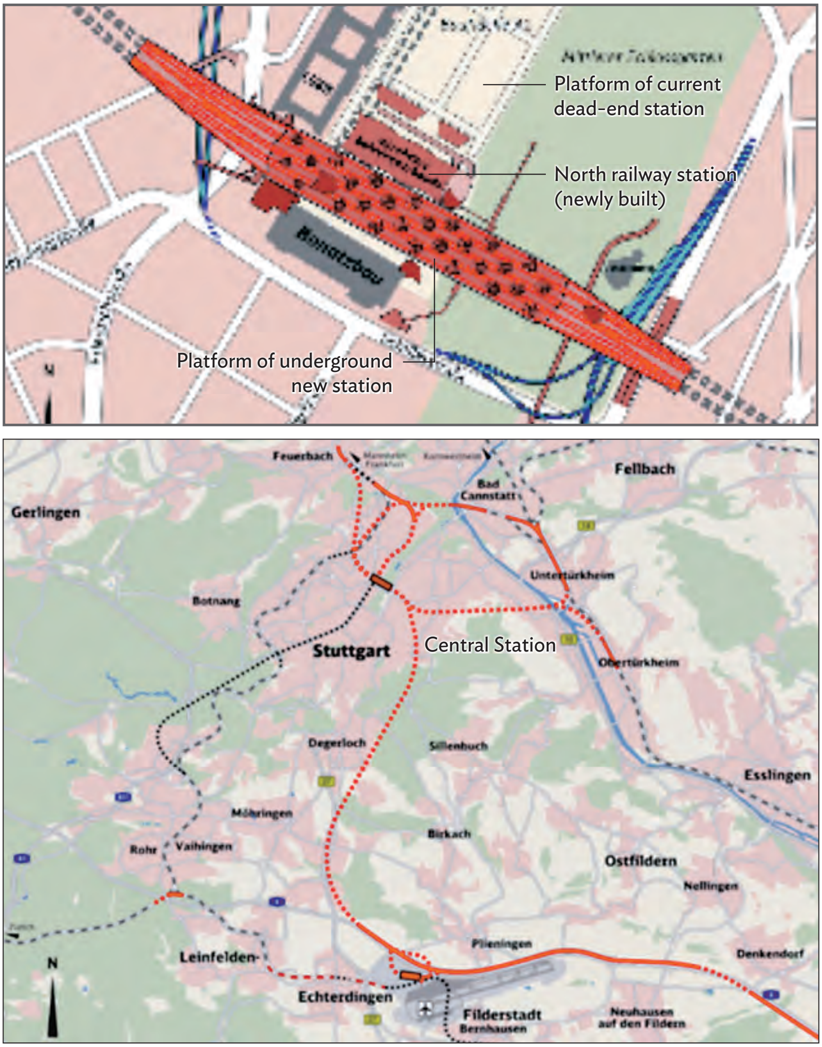
The first is Munich's new airport, which opened in 1992. After development of the plan to construct this airport in the suburbs of Munich in 1979, 5,724 lawsuits were raised by residents who were concerned about the environmental impact. Despite the many litigation cases, the trials were concluded in a relatively short period and the legitimacy of the project was validated. This was partly because a German special court system, called the administrative court, was able to examine multiple cases at once by classifying them by type. Meanwhile, those processes provided an opportunity to incorporate the requests

Munich Airport. The use of an administrative court sped up the handling of many lawsuits and provided an opportunity to incorporate citizens' feedback (photo by Michael Fritz/Munich Airport).

of residents. For instance, the size of the airport was changed, and coordination with the surrounding area in terms of land use was also adjusted. As a result, although its construction began after that of Narita International Airport in Japan, the German airport was completed first, and now it functions as a huge hub airport in southern Germany. In the case of this project, it is said that the appropriate and effective site utilization plan of Munich-Riem Airport, which was going to be a scrap port, also had a positive impact on the consequence in the court.

The other project that stands out as a success despite a difficult situation is the large remodeling project of Stuttgart Central Station (Figures 2.5 and 2.6). This station had been inferior in the operational efficiency of trains because it was a dead-end terminal station. A spectacular railway improvement plan proposed in 1988 aimed at constructing a new underground station and high-speed rail perpendicular to the current railroad. The new railroad would be a new arterial trunk line train running across the underground of the city. However, this project provoked strong protests from residents since its scale would be too enormous and it could cause serious environmental problems, resulting in a nationwide political issue. After various discussions by many groups over many years, a large-scale referendum was held in 2011, targeting residents in the whole province including the city of Stuttgart. As a result, the affirmative votes outnumbered the

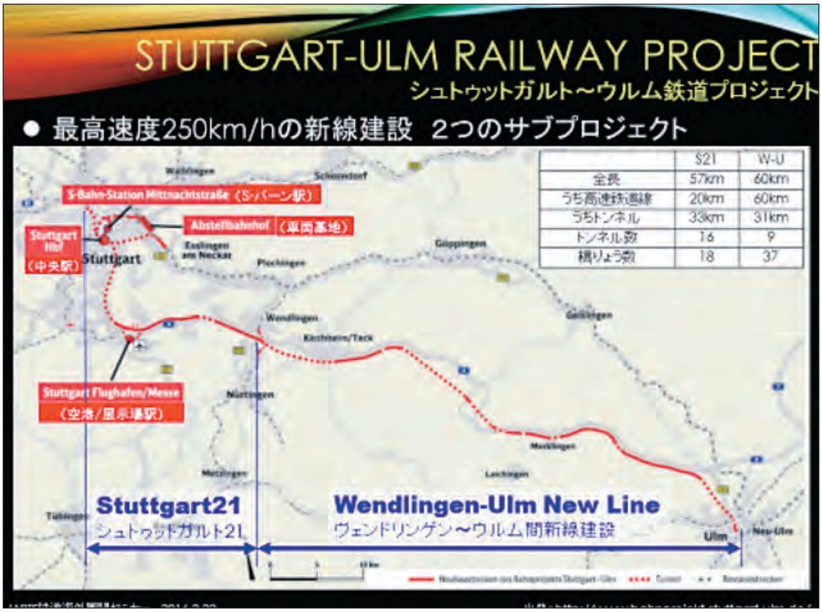
Figure 2.5: Remodeling Plan for Stuttgart Central Station



Source: University of Stuttgart.

negative votes and finally the construction project began as a project by the German federal government and the German railway (Deutsche Bahn). It is expected that the completion of the project will bring great development to the Stuttgart area by transforming the city to a crossroads of Europe's high-speed railway network.

Figure 2.6: Stuttgart 21 Project



Source: Hiroshi Shimoōzono.

2.3.4 Permission and Establishment of Business Entity

As infrastructure semi-permanently influences society, it is subject to various regulations at each stage of implementation. Also, since much of the financial resources are funded by public organizations, a project must ask for judgment and approval from the government or a public organization. Therefore, when implementing, it is necessary to negotiate with a few public institutions and obtain permission.

With what kind of institutions do project promoters have to consult? In addition, what kind of approval and authorization will be required depending on the type of project and target area? Here, as one example, let's have a look at the procedure in continuous grade separation road-rail crossing projects, which have been widely advanced in many cities in recent years.

This type of crossing project takes existing railroads and elevates long sections of them or installs them underground. The projects are carried out as urban planning road projects with the main purpose of eliminating traffic congestion at railroad crossings. Since an agreement on this issue was signed between the Ministry of Home Affairs and the

Multilevel Crossing Project (Kyōdō, Odakyū Line). Projects like these alleviate traffic congestion and make the urban landscape more cohesive (photo by Odakyū Electric Railway Co., Ltd).

Ministry of Railways in 1940, many projects have been completed in about 150 sections nationwide, including the JR Chūō Line in Tokyo. Besides alleviating road congestion, these projects have had impacts such as uniting districts formerly divided by rails and improving speed of transport. Also, it should be noted that the business entity of the project is a local public organization, while its implementation is carried out by a railway company. It is typical that the railway company bears about 10% of the project cost and the public side bears about 90%. (The national and local governments each bear half of this 90%.)

Below, we show what kind of consultation was made at the principal stages of these projects between the public institutions and railway companies, and what results are authorized and approved. Figure 2.7 summarizes these topics based on the data from the Ministry of Land, Infrastructure, Transport, and Tourism. Also, if there are procedures related to environmental assessment, we omit them here for simplicity.

In large-scale projects, it is sometimes necessary to create business entities as new organizations so that they can comprehensively manage the project, including the financial aspects. For example, in the Honshū–Shikoku Bridge Project, the Honshū–Shikoku Bridge Authority was established on legal grounds. In this way, they succeeded in gathering human resources from the public and private sectors and the bridge construction project connecting Honshū and Shikoku began in earnest.

A plan rarely progresses toward commercialization as originally anticipated, and it usually becomes refined over time. Not a few ideas are dismissed in these processes. This will be discussed further in the following section.

Figure 2.7: Discussion, Permission, and Authorization on Multilevel Crossing Projects

1. Adoption of Government Subsidy

Organization / Business	Central government (city bureau)	Local government	Railway company	Central government (railway bureau)
1. Government subsidy investigation	Adoption ←	Application Request →	Preliminary design	
2. Grant plan	Consent ←	Plan described		

↓

2. City Planning Decisions (Except Environmental Assessment Procedures)

Organization / Business	Central government (city bureau)	Local government	Railway company	Central government (railway bureau)
1. Creation of city plan	Answer ←	Prior discussion →	Answer Inquiry →	Answer
2. City planning decisions	Consent ←	Public announcement/ Inspection City Planning Council Consultation with Minister of MLIT Decision notice →	Change request of railway facilities →	Permission Consent

↓

3. Approval of Urban Plan

Organization / Business	Central government (city bureau)	Local government	Railway company	Central government (railway bureau)
1. Detailed design		Discussion →	Answer	
2. City planning projects	Permission ←	Project approval		

↓

4. Execution of Projects

Organization / Business	Central government (city bureau)	Local government	Railway company	Central government (railway bureau)
1. Implementation agreement		Conclusion ↔	Conclusion	
2. Execution of projects		Trust →	Enforcement	

MLIT = Ministry of Land, Infrastructure, Transport, and Tourism.

Source: Summary based on data from MLIT.

2.3.5 Modification of Concept

Once infrastructure is completed, it will have a semi-permanent effect on the society and the environment in the surrounding area. For this reason, intense conflicts sometimes occur, particularly at the planning stage, between stakeholders with different interests and values. Such confrontation sometimes leaves a root that grows into future problems. In this subsection, we will introduce projects whose achievement was enabled by creating a proposal accepted by both sides—those with positive and negative opinions—through dispute and confrontation for many years. The outcome of these projects has been extremely meaningful for the regions.

National Highway No. 5 is the two-lane road running in the center of Otaru City in Hokkaidō, Japan. The rapid increase in traffic volume due to motorization had become a serious problem, intensifying the congestion of this road and the surrounding urban center in the latter half of the 1960s. Therefore, the city officials planned a new six-lane road called Otaru Harbor Line in the seaside area as an alternative to this national highway, which would have been a difficult road to expand.

The plan proposed in 1966 was to reclaim the Otaru Canal. The canal had been built by digging the coastal land in the 1920s to support the function of the port by inland shipping using barges. For one thing, since the port became well developed and did not require inland shipping, Otaru Canal was no longer used effectively and was reduced to an anchorage point for small boats. For another, the settled sludge gave off a stench that kept people away. So to speak, it made dead spaces in the canal. These reasons are why the city came up with the idea of reclaiming Otaru Canal. In fact, there were many cities in Japan where rivers and moats were reclaimed in the 1960s for similar reasons.

However, around the canal there were still many stone warehouses built in the Meiji and Taishō periods. Citizens concerned about damaging this precious cultural heritage formed a group to protect the Otaru Canal and insisted that the canal should be preserved by creating a green space instead of roads.

In response, the city reviewed several alternative plans to construct a new route without reclaiming the canal area. However, they concluded that the original plan was optimal, considering the urgent need to mitigate urban traffic congestion and the increasing tendency to use truck transportation to move items from the port. The conflict of opinions between people pushing for full preservation of the canal and the urban planning project side was heated and was even taken up in the Diet.

The importance of preserving the historical environment was also shown in the Third Comprehensive National Development Plan of 1977, which indicated that the issue was already a big concern nationwide at the time. Thanks to the growing conservation movement, the city officials pursued, while adhering to the judgment that the Harbor Line was necessary, both the construction of urban planned roads and the conservation of historic heritage. In this context, a new plan for the development of Otaru Canal and the improvement of its surrounding environment was announced in 1979 based on a new draft plan prepared by a third party. The idea was to keep the new roads on the mountain side to leave the canal part as long as possible, to set up walkways and small plazas in the area to create a comfortable waterfront space, and to preserve and maintain the stone warehouse group on both sides of the canal as a scenic district.

Since then, players in the local industrial sector like the Chamber of Commerce and Industry, which had been advocating the construction of the Harbor Line, gradually changed their initial opinion and began to support the policy of preservation and redevelopment of the canal district. Under these circumstances, the stakeholders on both sides tried to compromise with each other with the help of the local government of Hokkaidō. Finally, they succeeded with the revised plan in opening the new roads and improving the environment of the canal district to increase the appeal of the city by preserving the waterfront.

Otaru Canal area. The redevelopment of this area created a beautiful urban landscape and improved traffic (photo by Otaru City, Hokkaidō Prefecture).

The Otaru Canal area redevelopment project was completed in 1986, creating a beautiful urban landscape in which historic buildings were preserved while securing smooth city traffic. Moreover, while the conventional industry in Otaru is currently declining, this district has been taking a great role as a new tourism spot.

2.4 Advancing to Realize the Idea of Infrastructure

Processes taken to realize the vision of infrastructure vary from case to case. For example, disaster relief projects are urgent and must be executed promptly. Also, projects advance in a relatively short time if they have a large influence on people's lives and the economy. In contrast, regional development projects, the significance of which people don't necessarily see, could require 20 to over 30 years to be commercialized. In this section, we are going to look at the past best practices for better understanding of each case.

2.4.1 Host of an Event

Large events like the Olympics or exhibitions can be a strong driving force of projects. In this case, most projects are related to the construction of transport facilities and urban facilities around the site that are necessary for the event. Not only international events but also small public events like national sports festivals promote projects so that the event can be held on time. This is driven by the need to meet the deadline in every process of securing revenue, site acquisition, approvals and licenses, and construction. In Germany, for instance, cities take turns holding an event called the International Garden Show so that they can carry out urban afforestation and improve the environment and urban facilities.

There are many examples of events that accelerated the development of infrastructure, such as the maintenance of streets in Tokyo or the urban expressway network triggered by the Tokyo Olympics, and the development of traffic and local infrastructure in Osaka in preparation for the Osaka Expo. As a representative example among them, let's have a look at the case of the Nagano Winter Olympics and the Nagano Shinkansen.

The Nagano Shinkansen runs between Takasaki and Nagano and it is a part of the Hokuriku Shinkansen, which was completed in April 2015. Its service between Takasaki and Nagano began in October 1997 in advance of the Nagano Olympics in 1998, which marked the first opening of the planned five shinkansen projects in Hokkaidō, Tōhoku, Hokuriku, Kagoshima, and Nagasaki. In 1991, before Nagano was selected as the host city, the government and the ruling parties had agreed that opening

Nagano (Hokuriku) Shinkansen/Second Chikuma River Bridge. This is one example of infrastructure development facilitated by an event (photo by Japan Railway Construction, Transport and Technology Agency. A Prosperous Future Starts Here. Japan Railway Construction, Transport, and Technology Agency. http://www.jrtt.go.jp/11English/pdf/Summary03.pdf).

the Nagano Shinkansen would take top priority if Nagano was selected, and the project was accelerated following that agreement.

Despite the difficulty of land acquisition along the railway line, it was accomplished at an unprecedented speed for a Japanese public project in time for the Olympics. As for the Nagano area, they held a council in each of the 19 zones, which contributed to acquiring about 40 hectares of the land in the short term. Moreover, the public opinion that the shinkansen was essential for the success of the Olympics is said to have been the key to the promotion of land acquisition and construction.

2.4.2 Accidents and Disasters

Though safety is one of the most basic and important factors in our lives, its importance is hard to notice in peacetime, so the improvement of facilities is likely to be regarded as secondary and be put off. But once an accident or disaster occurs, the insufficiency of measures is pointed out, which encourages the realization of projects. In this subsection, the case of the Seikan Tunnel is cited as an example in which an accident accelerated the realization of the project. The Seikan Tunnel, opened in 1988, is a 53.85-kilometer (the world's longest) undersea railway tunnel with its track located 240 m below sea level connecting Tsugaru

Peninsula in Aomori with Oshima Peninsula in Hokkaidō. Connecting the main island of Japan with Hokkaidō by an undersea tunnel was surely one of the biggest projects in the 20th century. While the project was accomplished in 1988, the idea itself was actually old, stemming from a proposal by Yasuo Kuwahara, a structural engineer in the Ministry of Railways during World War II. In 1946, after the war, a board was set up to investigate a connecting tunnel for the Tsugaru Strait. They started geological investigation above ground in that year and under water in 1953, but the progress was quite slow.

Then, in September 1954, a ship called Tōya Maru going between Aomori and Hakodate had an accident. Faced with strong wind and waves caused by a typhoon, it capsized and was blown sideways onto Nanae Beach of Hakodate Bay, killing 1,172 people. This had been caused by the unprecedented speed and high winds of the typhoon and inappropriate responses to the wind.

The accident stimulated demand among the people for the construction of the Seikan Tunnel, and the preparation progressed at a rapid speed. As a first step, they managed to start the construction of an investigative inclined shaft on the Hokkaidō side. Later, through numerous challenges and failures, including large-scale flooding accidents that could have led to submersion, the tunnel was completed in 1988, and eventually the railway was opened between Hakodate and Aomori.

With respect to this project, where it took as many as 50 years to complete the tunnel after the concept arose, it is clear that the momentum toward safe transportation triggered by the Tōya Maru accident encouraged the realization of the concept. Yutaka Mochida, a director of the Seikan Tunnel construction at Japan Railway Construction Public Corporation, said in his book, "It should be clearly written that the Seikan Tunnel did originate from respect for human life, i.e., the intention to build transportation without tragedy anymore, rather than from the purpose of economic development in Hokkaidō and Tōhoku, and strengthening sociocultural bonds."

2.4.3 Demand Pressure

Significant excess of traffic demand over supply depresses social welfare through congestion. People can face a drastic shortage in a period of economic growth like in Japan since the 1950s. Demand pressure can encourage new construction and reinforcement of structures among not only users but the whole community and citizenry, and can accelerate the realization of the concept. Let's look at the Tōkaidō Shinkansen as an example of realization developed by demand pressure.

It is well known that the concept of the shinkansen started from the Bullet Train Plan, which was approved by the Japanese parliament in 1940 just before the Pacific War. The plan was to operate a railway of about 1,000 km connecting Tokyo with Shimonoseki at a maximum speed of 200 km per hour. Although the railway was supposed to be constructed at a cost of ¥550 million over fifteen years, the construction was stopped halfway because of the war.

It was during the period of post-war economic growth that the project progressed in earnest. Rapid economic growth in the 1950s brought a surge in transportation demand on the Tōkaidō, the most important route in Japan. Hence, the Tōkaidō Line, which was the conventional train line that had been operated since before, needed to enhance its transport capacity in order to deal with the booming demand in both passenger and freight transport: the limited train was always fully booked, and freighting caused congestion at stations.

Shinji Sogō, appointed president of Japanese National Railways in 1955, insisted on building the Tōkaidō Shinkansen with standard gauge to improve the transport capacity of the Tōkaidō Line. Standard gauge is superior because it makes railways faster, safer, and more comfortable despite its cost, requiring more land and large cross-sectional bridges and tunnels. After considerations within Japanese National Railways (JNR) and the Transport Ministry, the shinkansen was going to be constructed in five years as an advanced transportation system at the world's highest level. In 1959, furthermore, Tokyo was selected as the host city of the 1964 Olympics. Challenging land acquisition was carried out with a sense of mission to finish the project in a short time. Later, the construction in big cities such as Tokyo, Yokohama, Shizuoka, Hamamatsu, and Nagoya started one after the next, with work being rushed to meet the deadline. Despite the great need for budget procurement and the difficulty of land acquisition, there is no doubt that demand pressure derived from rapid economic growth, as well as the necessity to be ready before the Olympics, boosted the completion of the shinkansen. Within this context, it was opened on 1 October 1964, just five short years after construction began.

The next project is that of Kurobegawa No. 4 Hydro Power Plant, another challenging project to handle demand-supply gaps done in a short period of time. Japan began to restore its economy in the 1950s as it recovered from wartime devastation. At the same time, electricity demand from industry and consumers grew steadily. However, electric power production did not increase very much, resulting in huge demand-supply gaps, especially in the Kansai region, including Osaka. In 1951, when the power shortage was most serious due to a decline in thermal power generation because of the quantitative and qualitative deficiency of coal in addition to a decline in hydroelectric power generation because of drought, Kansai Electric Power Co., Inc. had to stop power distribution to large power users two days a week and toward general households three days a week.

In order to overcome the electricity shortage, the company decided to build a large dam in a canyon in the hinterland of Kurobe River, and installed the large-scale No. 4 Power Plant. They not only aimed at increasing power generation especially in winter by discharging the dammed water, but also attempted to supply power efficiently. The idea was based on the fact that thermal power generation is suitable for providing a constant amount of electricity because it is hard to take full control of electricity production, and that hydropower generation is able to provide electricity flexibly in response to its peak load.

Regarding financing, they raised an enormous amount of money from their own funds and foreign funds utilizing World Bank loans authorized by the government.

The dam is located in a deep gorge inside a national park, which is sandwiched between the 3,000-meter-high Northern Japan Alps. The 186-meter-high arch dam was planned to generate a maximum of 260,000 kW (at the beginning) by using the potential energy of falling water with its 545.5-meter drop. All the facilities, including the power station, were planned to lie underground to preserve the beautiful nature of the national park.

Ensuring a transportation route for construction materials was the top priority when it came to the construction of a gigantic dam and powerhouse in this gorge. The construction of a tunnel on a road through Ōmachi in Nagano and the Ushiro-Tateyama Mountain Range was so demanding that it was almost given up; a fracture zone was encountered along the expected route of the tunnel, causing huge water runoff. The problem was overcome by technical and construction measures. The opening of this route enabled them to transport a lot of equipment and big power-generating facilities to where the dam and powerhouse were being constructed.

Finally, the power company and the construction companies, thanks to their dedication and technology, accomplished this challenging work seven years later in 1963. The dam contributed significantly to generating more electricity not only in Kurobegawa No. 4 Hydro Power Plant but also in a group of downstream powerhouses, which overcame the electricity shortage in Kansai region. The route to Kurobe No. 4 Dam, which was forged deep in the Northern Japan Alps in order to build this dam, is known today as the Tateyama Kurobe Alpine Route, and attracts many tourists to this hidden beauty.

Kurobegawa No. 4 Hydro Power Plant. This project not only provided needed energy but also brought tourists to a previously hidden area.

2.4.4 Type of Business

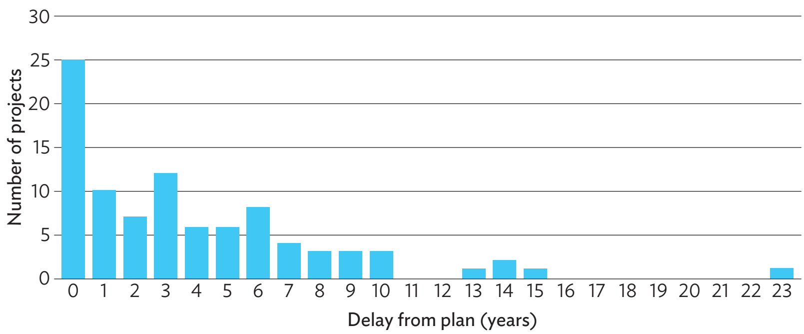
When constructing infrastructure, projects can be categorized into two types of business: public projects and corporate projects. Public projects are operated by national or local governments (e.g., river construction work and construction of general roads), while corporate projects are operated by a business entity including a public corporation (e.g., construction of toll roads and railways). Differences between the two kinds of projects could affect the speed at which projects are completed. In this subsection, we clarify how the difference between the two business types affects the speed of a project.

First, let's look at the progress of construction of general roads in Japan as a typical example of public projects. In order to discuss the speed of a project, we focus on the gap between its planned construction period and the actual construction period. Figure 2.8 indicates how many years the past repair projects of national highways actually required compared to their planned schedules, which was investigated when the private finance initiatives research subcommittee of the construction management committee of the Japan Society of Civil Engineers surveyed the offices of rivers and national highways across Japan as a commissioned business from the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT). Approximately three quarters of the projects missed the deadline, ranging from being a few years to ten years late. No projects were completed ahead of schedule.

Next, we are going to look at the progress of railway construction as a typical corporate project. Figure 2.9 indicates the situation of Japan's railway projects in the same way as Figure 2.8. Although the figure shows that about three-quarters of projects missed the deadline like the designated national highways in Figure 2.8, they were completed within 2 years of the schedule and one-fifth of projects were in service even before the deadline.

These cases show that corporate projects are more likely than public projects to be realized faster with a shorter construction period

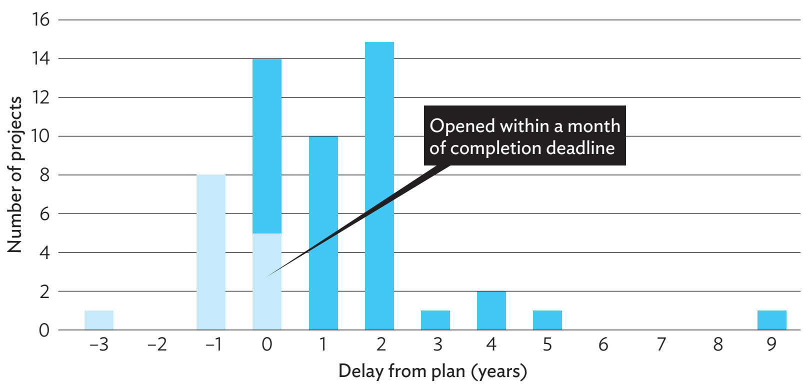
Figure 2.8: Delay from the Plan (National Road Renovation Projects)



Note: Commercialization: When construction budget is allocated to a project and it commences.

Source: JSCE Construction Management Committee PFI Research Subcommittee. 2004. *Road-Related PFI Projects Risk Analysis.*

Figure 2.9: Delay from the Plan (Railway and Tramway Projects)



Source: Atsushi Hasegawa. *A Study of Social Capital Development Project Implementation Management from the Perspective of Time Management Concept*.

and potential early completion. A variety of factors affect the speed of completion, such as financing, legal restrictions, technical problems like process planning and process control, and the progress of consensus building on site acquisition, but financing methods and legal restrictions seem to be the most influential factors for different business types.

Differences in financing methods or interest rates affect the incentive to shorten the construction period and accelerate the opening. Corporate projects are mainly funded by interest-bearing debt that will be repaid with the money collected after opening, which means that earlier opening is preferable to reduce the burden of interest. On the other hand, public projects are funded mainly by tax revenue, which means that they do not have to rush the project to reduce the interest burden.

Legal restrictions also influence the length of the construction period. There are a variety of restrictions when promoting public projects. For one thing, the Public Accounting Act and the Local Autonomy Act stipulate that infrastructure construction needs to be funded only with a single-year budget. This means that a budget of one year cannot be used in a different year, which makes it difficult to front-load the work of a multi-year project. Although during the period when the budget execution is pending, there is a system that allows for the flexible use of budgets and is applied to some multi-year projects, there are still few cases that accelerate next-year work. The same is true of the case of conducting multiple projects. Even when the project of a particular fiscal year is completed, they cannot work on the next fiscal year's projects until the budget has been implemented. For another thing, most contracts in public projects do not have a bonus system when the construction period is shortened. Rather, contractors are obliged to pay delay damages only when the construction is delayed, which does not serve as enough incentive to shorten the construction period.

Besides the above factors, private finance initiatives (PFIs) and public–private partnerships (PPPs), which both attempt private sector participation, have gotten a lot of attention recently as a new style for constructing infrastructure. Introducing these aids early project completion as well as cost reduction and risk management.

2.4.5 Foreign Situations

The implementation of infrastructure sometimes depends on international relations. When a project arises, the country where the relevant structures will be constructed usually makes decisions on its own, but in some cases, other countries intervene in the decision making from the perspective of diplomacy. This is because infrastructure has a big effect on the current account and trade balance through expansion of domestic demand. This kind of effect is exemplified nowhere better than in the Structural Impediments Initiative (SII), which was held from 1989 to 1990.

While SII was formally expressed as a Japan–US comprehensive negotiation that mainly intended to resolve trade friction, it was virtually recognized as a Japan remodeling program. In the late 1980s, Japan and the US had a major challenge in the imbalance of payments equilibrium between the two countries. The US enacted the Omnibus Foreign Trade and Competitiveness Act of 1988, including Super 301, which attempted to specify countries causing import barriers and market distortions and allowed retaliatory action against those countries.

In these circumstances, the President of the US proposed SII to the Japanese Prime Minister through a Japan–US summit in 1989. As it was a bilateral discussion, there were Japanese demands on the US, but the primary purpose was for the US to demand Japan to open its market. In response to the discussion in 1989, the discussion held in 1990 determined that Japan had an obligation to invest approximately ¥430 trillion in infrastructure development over ten years, pointing out that Japan needed to further expand domestic demand to resolve the trade imbalance. The investment later increased to 630 trillion in the mid-1990s, used for the construction of Kansai International Airport, development of Tokyo Waterfront City, and construction of roads connecting local cities.

All the target projects had been considered even before SII. For example, the development of Tokyo Waterfront City had been considered since the early 1980s in Tokyo.

Following the contemporary global trend of waterfront developments, such as in Lower Manhattan in New York and in the London Docklands, basic concepts for waterfront development were announced in 1987, with the expectation that international urban facilities like an international exhibition center, office buildings, and residences would gather in the 440-hectare area around the Ōme, Ariyake, and Daiba districts. Regarding this concept, the Rainbow Bridge, New Transit Yurikamome, Rinkai Subway Line, and Shuto Expressway Route 11 were planned to be constructed as transportation infrastructure in this area. Part of ¥630 trillion was allocated to these developments, which accelerated their realization.

The reason why the US forced Japan to expand domestic demand was that the US wanted to protect its own interest by resolving the trade imbalance and even by changing Japanese systems and policies including the increase of public investment. In this sense its diplomatic pressure was overwhelming. Nevertheless, that does not mean that the public work, such as the development of Tokyo Waterfront City and Kansai International Airport, was unnecessary. Waterfront City has contributed to the improvement of Tokyo's position among global cities, and Kansai International Airport has played a prominent role in business and tourism as an international hub airport in the Kansai region. Also, these public investments shored up the post-bubble economy. It is true that the foreign pressure of SII accelerated the already-planned public projects and that they were constructed in a remarkably short time for Japan's time-consuming large projects.

2.5 Failure in Promotion of Infrastructure Concepts

Some concepts that have been built at the cost of collective wisdom, time, and effort can be discarded along the way and fail to reach commercialization—and even if they did, they could be stopped partway through. There are a variety of reasons for such failures, and we will look at the primary reasons through examples.

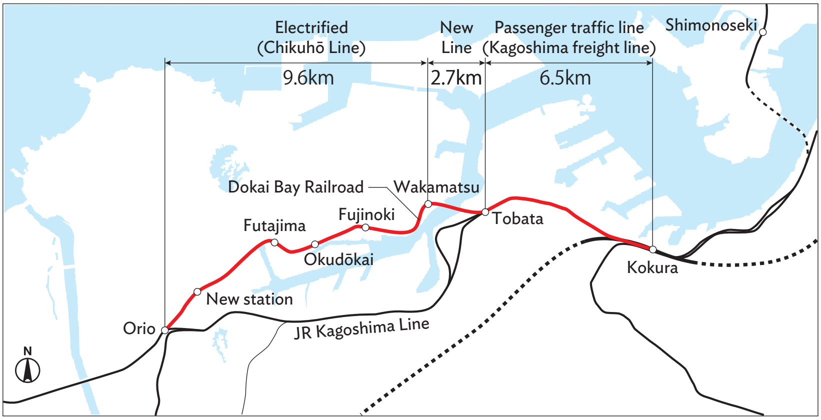
2.5.1 Financial Challenges

The financial resources that governments or other public bodies set aside for the infrastructure industry are limited, as might be expected. It follows that many infrastructure concepts are not realized as planned because of a lack of funds, even if they would bring enormous social benefits and would be worth investing in.

The concept of a project is often cancelled, or the commercialization is suspended because of difficulties in raising funds or ensuring the profitability of the project, even in the case that the project includes a profit-making system like toll collection. These sorts of difficulties can arise in both public and private sector projects. Among the cases that have faced financial challenges, the rail plan in Kitakyūshū City is one representative example.

In Kitakyūshū City, a long and thin channel-like bay called Dokai Bay runs deep into the land (Figure 2.10). Wakamatsu Ward is located at the north of this bay, and its port was used to ship coal coming from Chikuhō Coalfield. On the opposite shore is the industrial zone Tobata Ward, and its east neighbor is Kokurakita Ward, the center of the city. While the gently undulating hilly geography of the peninsular Wakamatsu Ward is potentially highly attractive for both educational and residential use, it has little access to the adjacent cities, such as Tobata or Kokura. Although Tobata Station is just a kilometer away from

Figure 2.10: Conceptual Plan of Dokai Bay Railroad



Source: Based on Institution for Transport Policy Studies. 2001. *The Study on Development of Dokai Bay Railroad*.

Wakamatsu Station, the two points were split by Dokai Bay, and most people had to cross Wakato Bridge to go between the two cities, causing traffic congestion on the bridge.

That is the reason they planned in the late 1990s to build a new 3-kilometer railway in these areas. The plan was to extend the Chikuhō Line, which had not been used after coal shipping stopped, from Wakamatsu to Tobata by constructing a new railway including a 2-kilometer tunnel under the bay. Furthermore, they intended to connect Wakamatsu and Kokura with a 12-minute trip by making use of the existing cargo rail track. This project was expected to create a great neighborhood of residences and schools in Wakamatsu, which could lead to the urban development of the whole city.

However, the budget estimate revealed that the railway service was running at a deficit every year after opening; the estimated project cost was ¥21 billion, and they needed a grant of ¥500 million every year to pay for the project. JR Kyūshū, the private company that operates a transportation network in Kyūshū, was of course reluctant to take on the project on its own. As an alternative plan, commercialization using a national grant from the Convenience Enhancement Project for Urban Railways had also been considered for several years since 2005, but the railway concept disappeared completely because of the projected deficit and also because a new underground road under the bay was constructed as part of the port industry.

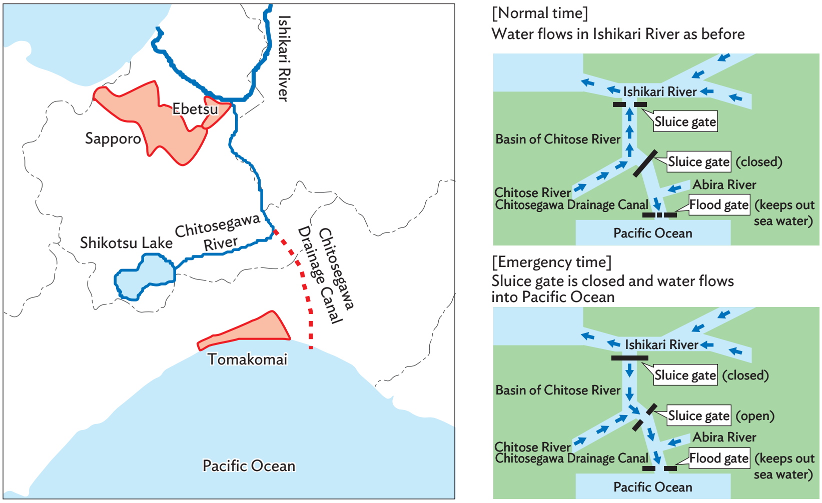
However, the financial challenge mentioned above could be solved by taking advantage of certain urban policies. For example, there was a possibility that the project could have gained additional income equivalent to the rise in land prices due to the transportation improvement, if they had built up the system appropriately. Given the effect on the long-term urban growth of this area in the future, this project to make use of wasted rail assets to develop cities deserved more serious consideration.

2.5.2 Environmental Concerns

The infrastructure industry inevitably affects the existing environment since it builds structures on land and in nature. Today, in advance of commercialization, an environmental assessment is conducted to verify that the various impacts on water quality, air quality, noise, and the ecosystem are acceptable. Still, this may not be enough to dispel concerns over the future, and a campaign against a project may be launched. In response to this, an operator may take measures and changes its plans to promote a project. If the campaign still goes on, the dispute is settled with an independent committee like an expert committee. The channel plan of Chitose River in Hokkaidō is an example of a concept dismissed through such processes (Figure 2.11).

The river, an outflow of Lake Shikotsu, flows through the low-lying area of Chitose City before it flows into Ishikari River in Ebetsu City. But when the water level of Ishikari River rises, the water of Chitose River that cannot flow into Ishikari River triggers floods in the lower reaches

Figure 2.11: Plan of Chitosegawa Drainage Canal



Source: Based on *Magazine of Japan of Society of Hydrology and Water Resources*. 1997. Plan of Chitosegawa Drainage Canal. 10(5).

due to the difficulties of drainage. In such a situation, the channel plan of Chitose River, compiled by the Hokkaidō Regional Development Bureau in 1981 after the massive flood of that year, stated that they would build a floodgate at the confluence with Ishikari River and a 40-kilometer discharge channel, and during floods they would discharge the water of Chitose River to the Pacific Ocean instead of to Ishikari River, in order to protect from the danger of floods. This plan was determined as a flood control measure of the river in 1982, when the basic plan for the implementation of construction of the Ishikari River system was fully reviewed by the river council of the then-Ministry of Construction.

While Chitose, Eniwa, and Ebetsu were in favor of this big project that would last for 20 years, Tomakomai, part of Chitose, and Hayakita, where the project would potentially affect their environment although they were strangers to floods from the river, launched a campaign against it.

The primary reason was that it would have a lethal impact on the ecosystem on the Pacific Coast, into which the water would be discharged, and on the nature of the beautiful Bibi River and Lake Utonai, which was designated as a bird sanctuary. Hence, they proposed comprehensive flood control, such as the improvement of Ishikari River, in addition to expansion of floodlands and development of forests for flood prevention instead of flood control using massive infrastructure like the discharge channel.

Heated debates spanned many meetings over a dozen years or so. Eventually, based on a report from an exploratory committee consisting of experts on the environment, agriculture, fisheries, economics, and river engineering, the governor of Hokkaidō suspended the plan in 1999 and submitted to the then-Hokkaidō Development Agency a written statement in support of comprehensive flood control. This is how the government decided to discontinue this plan.

Other reasons for the discontinuation were insufficient dialogue on the environmental debate with the residents involved since the early days of the concept, and the conflict between regions with different interests. However, considering concerns over the future torrential rain, the question remains whether this judgment was appropriate as a permanent measure.

2.5.3 Difficulties in Land Acquisition

When it comes to the infrastructure industry, which involves land improvement and construction of facilities, it is vital to acquire necessary land from landowners. Landowners are likely to refuse to give up their land rights because of environmental concerns, psychological resistance to the loss of ancestral land, and unsatisfactory compensation. That is why operators always struggle with the acquisition of commercial land.

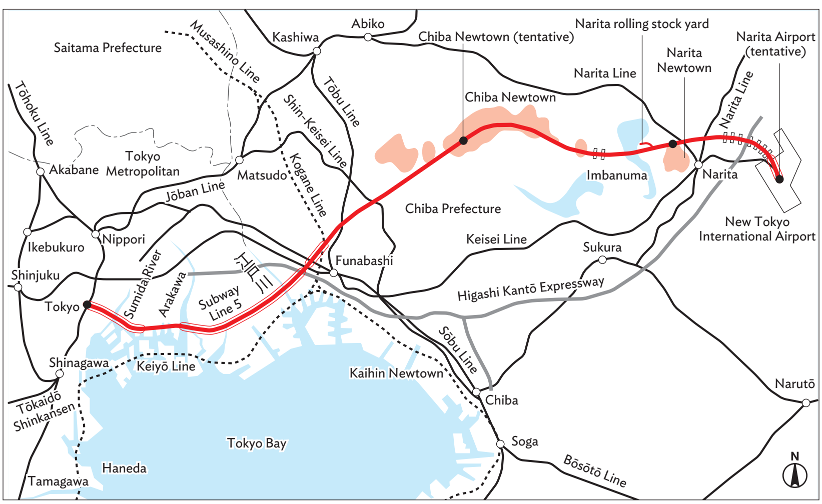
When a project is essential for the common good, they can use legally compulsory measures of land expropriation, but enforcement requires a lot of processes and time and prompts social debate. Besides, it becomes impossible when local leaders or councils object to the project, or when an expropriation committee is dysfunctional. In that case, the project cannot be fulfilled even if it is socially essential.

Take the Narita Shinkansen project as an example (Figure 2.12). It was discontinued because land acquisition turned out to be impossible part-way through the project.

New Tokyo International Airport, or Narita International Airport, which was newly constructed to meet a greatly increased demand for an international airport, is located in Narita, Chiba, 65 km away from the heart of Tokyo. A shinkansen was planned to shorten travel between Tokyo and the airport to about 20 minutes.

The construction was started in 1974 by Japanese National Railways and Japan Railway Construction Public Corporation. The land acquisition required steadily went along in negotiable areas along the confirmed route, and the construction of subway stations at the airport and Tokyo Station was going smoothly. But many municipal councils adopted a resolution opposing the construction after the concerned residents launched a campaign against it for fear of noise damage.

Figure 2.12: Route of Narita Shinkansen



Source: Based on three decades of history of Japan Railway Construction Public Corporation.

This was followed by the opposition of Edogawa Ward and other municipalities along the route claiming that the project would bring no benefits and only trouble to the municipalities if the trains were just going to pass through them.

The shinkansen project faced fierce criticism as a symbol of an anti-airport campaign in the context of the controversial construction of the airport. After the governors of Tokyo and Chiba also advocated freezing the plan, which led to dysfunction of the expropriation committee, land acquisition became almost impossible and the project was frozen in 1983.

The rest of the project proceeded despite the stalled shinkansen project. Construction concluded at Tokyo Station, Narita Airport Station, and a two-kilometer track between the airport and the intersection with the Narita Line. A roadbed and elevated bridge around Etchūjima Freight Station were also constructed. In addition, they had already acquired the land such as in the New Town area (which became a planned residential area) along the way. But the prospect of the land acquisition in other disputed areas was so unclear that the government gave up on the project in 1986, 12 years after the start of construction.

The absence of a high-speed railway to central Tokyo was a potentially serious weak spot for Japan's international air traffic. To overcome this weak point, they explored an alternative approach to the shinkansen: they adopted the idea of installing the Narita Line and Keisei Line at the underground station of Narita Airport, which had already been constructed for the imaginary shinkansen. They were put in service in 1991 and are now called the Narita Express and Skyliner. Although the train line between the airport and central Tokyo was later built, the absence of the high-speed railway between the two had negatively affected Tokyo's accessibility from abroad for the first 13 years and after. Moreover, the poor access from the airport to Tokyo leads to insufficient cooperation with the shinkansen network connecting Tokyo and all corners of the country and therefore reduces the international competitiveness of not only Tokyo but the whole country. Considering the long-term future heavy losses throughout the country, they could have accomplished the initial plan of the shinkansen, even at the expense of partial underground construction for environmental conservation.

2.5.4 Regional and Political Conflicts of Interest

Conflicts of interest between regions that directly reap benefits from infrastructure development and those that do not, conflicts of opinion among local political groups, or changes of mind influenced by political speculation can often interrupt or cancel ongoing infrastructure projects. The salient example is Kyūshū International Airport, which was under debate from the 1970s to 2010.

Located in Fukuoka, with a population of more than one million people around 1980, only two km away from Hakata Station, the very convenient airport had contributed to the development of the city. However, being in an urban area, there was no small fear of unexpected aircraft accidents and noise, and urban planning was subject to building height restrictions regulated by the Civil Aeronautics Act. In addition, the land costs of the airport, more than 30% of which was privately owned, and environmental protection expenditures could not be disregarded. Despite the increase in demand, they could barely increase the number of flights at that time. It was almost impossible to expand this airport surrounded by an urban area.

In reaction to the problem, the chamber of commerce, followed by a group of young economists, suggested constructing a new international airport on the sea. Then, Kyūshū Economic Federation (KEF) and the Association of Kyūshū Governors (AKG) established the Kyūshū International Airport Examination Commission and announced in 1992 that Kyūshū needed an international hub airport. This started the investigation of six (eventually five) possible sites in three regions, but the difficulty of competing interests among prefectures forced them to give up choosing one for the moment in 1994. In 1995, to break the deadlock, AKG and KEF commissioned the Wisements Committee, which was newly established as an independent organization composed of outsiders to integrate candidate sites, to select the best site for the airport.

The committee suggested moving the airport completely onto the sea off the coast of Shingū and Tsuyazaki with a broad view, and AKG and KEF provided the same opinion to the then-Minister of Transport.

However, other prefectures of Kyūshū protested the idea that the new international airport would be built in Fukuoka. With the help of the prefecture and the city, therefore, the economic community of Fukuoka settled on the concept of the New Fukuoka Airport instead of Kyūshū International Airport and started work on the project. They were then able to promote the project independently from other prefectures.

While the promotion of new airport construction was one of the biggest issues of local politics in Fukuoka, the governor promised to take the basic concept back to the drawing board to avoid making it a point of contention in a gubernatorial election in 2003. Later, the local political leaders, including the governor, came out in support of expanding the current airport to deal with the overcrowded conditions, and so did the national government.

Now the airport is going to be expanded on the current location, and extra runways are under construction. Even if they are completed, they will not erase the fears of accidents possible in the urban airport and the limitation of upward building in the city. The Netherlands and two states in Southern Germany, of similar size to the seven prefectures of Kyūshū in terms of area and population, have their own international airports (Amsterdam, Munich, and Stuttgart), which contribute to the development of whole communities being directly connected to the world (Figure 2.13). The local politicians need to think from a broad perspective about whether Kyūshū can continue without an international airport connecting it with the world, instead having local airports in each prefecture.

Figure 2.13: Allocation of Airports in Kyūshū (Japan) and Netherlands

Item	Kyūshū (including islands)		Netherlands	
Area (km^2)	42,232		41,864	
Population (10,000 people)	1,302		1,705	
Number of passengers (10,000 people)	Fukuoka	2,100	Amsterdam Schiphol	4,800
	Kitakyūshū	130	Eindhoven	150
	Saga	60	Groningen-Eelde	20
	Nagasaki	310	Maastricht Aachen	30
	Kumamoto	320	Rotterdam	170
	Ōita	180		
	Miyazaki	290		
	Kagoshima	520		
	Total	3,910	Total	5,170

Sources: Ministry of Economy, Trade, and Industry; Ministry of Foreign Affairs; Tokyu Agency Inc.; Rotterdam Airport.

2.5.5 Changing Social and Economic Situation

Social trends of the moment can support, discontinue, or postpone a project. The conspicuous examples of projects that were promoted because of the economic situation are the Tennessee Valley Authority in the US after the Great Depression in 1929, and the Autobahn construction in Germany. Disaster prevention projects can also be influenced by public awareness, which rises after a disaster and then gradually fades. Here is an example of the growing and disappearing momentum of an idea to relocate the Japanese capital.

The discussion of relocating capital functions to a new city instead of Tokyo, where too many functions of the country's politics, government, economics, and culture are concentrated, started in the late 1950s in order to eliminate the harmful effects of the megalopolis, and came up as an issue in the Comprehensive National Development Plan, which was established by the government. After that, the Third Comprehensive National Development Plan in 1977 treated the capital relocation as an important issue of national development policy to prevent overconcentration on Tokyo. Subsequently, the Fourth Comprehensive National Development Plan, designed in 1987 when land prices were skyrocketing, requested decentralization of the population and functions in Tokyo in light of urban issues caused by its excessive concentration.

These actions in the government gradually facilitated discussions among the Diet. In 1990, the Diet concluded that the legislative and government functions should be relocated to make them appropriate for the 21st century. As a law on the relocation was enacted and the Investigation Committee for the Relocation of the Diet and Other Organizations was established, a series of discussions on its purpose, effects, and approach were held mainly with experts. They listed the benefits of the relocation: to make national land appropriate for the 21st century, to solve urban congestion, and to handle vulnerability to disasters like earthquakes.

When the disaster of the Great Hanshin Earthquake struck in 1995 in the large city Kōbe, people became eager to relocate the capital from Tokyo. The Council for the Relocation of the Diet and Other Organizations was established to discuss the concept and options for potential capitals with representatives from fields such as law, media, art, history, science, engineering, and medicine, who the Prime Minister designated as commissioners.

This council examined the idea of a city cluster consisting of hundreds of hectares of small cities placed several kilometers away from each other. The major advantages of this idea were eliminating the need for procuring a large area for a new capital and making it possible to preserve the good environment. Since the site selection needed to be carried out in a fair, transparent, and clear manner, separate meetings specializing in the environment, disasters, transportation, and economics were to help the council evaluate the candidate sites from a technical perspective. As a first step, they rated the sites in each meeting and then integrated the evaluation points with weighting factors determined by the council based on the importance of each element, which enabled quantitative evaluation. Eventually, the area near the border between Tochigi and Fukushima was recommended as the best site.

The concept was expected to be discussed further in detail, but the situation took a turn for the worse. Despite the agreement that the project had enough objectivity and transparency, it was met with nationwide criticism and complaint. It was criticized not only by the candidates not chosen but especially by Tokyo, which would have lost some or all of the capital function. Followed by a prolonged depression and the fading memory of the Great Hanshin Earthquake, political and ministerial movement to realize the concept was no longer seen.

Abandoning the project had mostly negative impacts on Japanese society. As overconcentration on Tokyo worsens, regional gaps are widening. Moreover, there is a high probability of a major earthquake in Tokyo, and the risk of severe damage is of even greater concern today because of growing overconcentration. Although the Capital Functions Relocation Planning Division in MLIT was later abolished and the government has made less effort to ensure the stability of the capital function, we need to reconsider this issue. For example, splitting the capital could also be worth discussing if relocating the whole capital is infeasible. Considering the current situation, a fundamental solution to the dangerous overconcentration in Tokyo is necessary for the sake of long-term stability in Japan.

2.5.6 Incompatibility with Regional Conditions

Infrastructure plans designed by a few people are sometimes pushed along by social trends. This can sometimes happen with a concept that is not necessarily well-adapted to the geographical, natural, and social conditions of the region. However, a concept that doesn't suit the circumstances will succumb to competition from other concepts sooner or later. Let's look at the example of an industrial development project in Akita Bay that was partially completed.

Suffering from population outflow caused by the decline of its primary industry, Akita Prefecture devised a plot to construct an industrial complex on Akita Bay to create employment and keep people from moving away. As a first step, it advertised itself as a new industrial city defined based on the Comprehensive National Development Plan, and was designated in 1966 as the new industrial city of Akita Bay area as a result. The original plan was to construct the complex mainly of the refinery, paper-making, and timber industries, making use of local resources such as petroleum and wood in Akita.

However, it barely broke into these expected industries due to oil production decline. The development project changed into the construction of a heavy chemical industry base where overseas materials were processed, in order to keep pace with other thriving heavy chemical industry bases such as in Kashima or Setouchi.

The comprehensive development plan in 1976 was to reclaim land with a width of 3 km from the coast of Akita Bay, create a deep-water industrial port, and construct a steel factory producing 20 million tons of steel per year on 5,000 hectares of industrial land. This development plan, however, had many problems, such as the distance from consuming regions in major cities, low competitiveness of the industrial land under harsh weather and nautical conditions, and unrealistic expectations of future demand. Furthermore, the environmental issues of existing heavy chemical industry areas, which were a growing concern at that time, sharpened suspicions against this project. Eventually, this concern disappeared along with the nationwide fading of new construction of heavy chemical factories in Japan.

Infrastructure projects, especially those aiming at regional development, cannot succeed unless they comply with the geographical, natural, and social qualities of the region. Considering that similar projects in Mutsu-Ogawara and East Tomakomai hit impasses and suffered in the aftermath, we would like to reiterate that projects must satisfy regional requirements. In this sense, the withdrawal was the right choice because the development project in Akita Bay was stopped at a comparatively earlier point, which prevented a big loss.

Bibliography

Section 2.1

Hanes, J. E. 2002. *The City as Subject: Seki Hajime and the Reinvention of Modern Osaka*. Berkeley: University of California Press.

Section 2.2

Homepages of Leipzig. Leipzigseen (https://www.leipzigseen.de/) and Der Spadener See (https://www.seen.de/spadener-see/)

Section 2.3

Heimerl, G. 2001. Zukunft der europäichen *Eisenbahnen. Eisenbahntechnische Rundschau (ETR)*.

Chapter

3

Infrastructure Commercialization and Business Entity

Your engineering spirit couldn't keep you with us, but it nurtured the nation and society of Japan, and will continue to do so forever.

— Kanzō Uchimura (1861–1930), Japanese Christian evangelist, in his funeral address to his best friend, Professor Isamu Hiroi, who devoted his life to constructing Otaru Port and others and later became a professor of Tokyo Imperial University.

3.1 Project Entity of Infrastructure

When an infrastructure idea put forward by a local organization or individual gains wide support in society, the question will be who should build that infrastructure and how.

Under the liberal economic system, consumers acquire goods and services through the market, and we expect that supply and demand will balance. But market failure is to be expected, and because of this the welfare (richness, comfort, equality, etc.) of society will be compromised. Typical examples are public goods such as roads. If roads are provided only by private companies, supply will tend to be short, so their use will be severely restricted. This will significantly hinder society's activities.

In reality, some infrastructure is supplied by the private sector, but a lot of other infrastructure is provided by the public sector because it has characteristics of a highly public nature, as mentioned in Chapter 1. For this reason, the public sector is the major infrastructure project entity. It can also be involved in various forms, such as investor and manager of infrastructure projects, provider of funds such as subsidies, and regulator.

There are many types of infrastructure projects and organizations involved with them. In some cases, public sector actors such as governments may conduct the project directly. In other cases, private enterprises may do it. There may be an intermediate entity that carries out the project. In addition, the project entity may handle the whole process including investment, planning, financial management, construction management, etc., or may conduct some part of it. Perhaps the most frequent case is where government agencies order businesses and private companies to undertake this. Next, we will discuss the requirements for infrastructure business entities. After that, we will take several examples of infrastructure and show what kind of project entity managed them.

3.1.1 Role of the Project Entity

The infrastructure project entity is an organization that executes and manages the infrastructure plan. There are three types of roles for project entities.

3.1.1.1 Preparatory Stage

Construction and operation of infrastructure requires a lot of preparation. In many cases, authorization by the relevant authority is required. The stages of preparation are:

- Survey
- Design and integration
- Consensus building (local organizations, administrative agencies, etc.)
- Application for licensing such as project approval

3.1.1.2 Construction Phase

Construction of infrastructure has the following stages. In general, the project entity does not handle the construction itself, and performs general management of land acquisition and procurement.

- Land acquisition
- Procurement (funds, materials, design, construction, etc.)
- Construction management
- Check of delivered items
- Payment

3.1.1.3 Operation Stage

The following operations occur in the operational stage of infrastructure. Normally, operations are done continuously and semi-permanently, but eventually this leads to updates or retirement.

- Business operation
- Maintenance and repair
- Toll collection (in certain cases)
- Financial management
- Crisis management
- Updates / Retirement

3.1.2 Types of Project Forms

As mentioned above, under the liberal economic system, various economic activities are conducted as private business in principle. However, since infrastructure projects have public characteristics, there are many cases where it is necessary for public sector actors such as administrative organizations to be involved in some way.

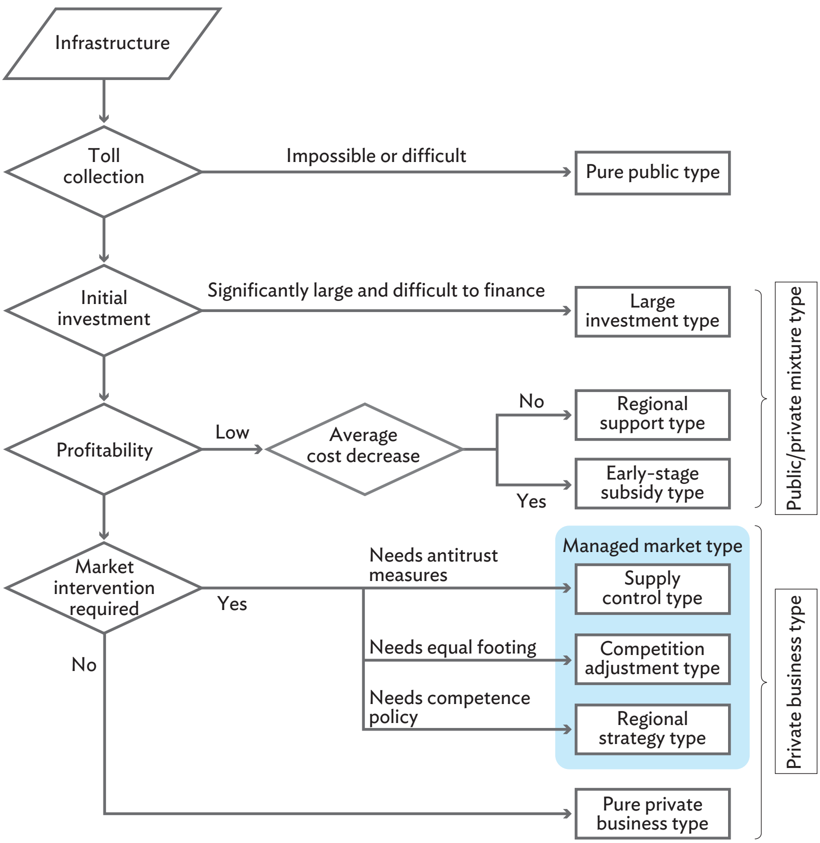
Intermediate business entities between public and private may be established in various forms. They utilize financial resources and credit, authority, human resources, etc. of public institutions such as governments, and incorporate funds, strategies, and management capabilities of private companies as necessary.

Various types of business entities carry out infrastructure projects: local public enterprises, regional unions, special corporations such as public corporations or government holding companies, third-sector companies, private finance initiative (PFI) business companies, and private utility companies that are restricted by government in business fields and/or pricing.

Thus, the forms of the infrastructure business can be written as follows: (i) those in which public institutions are the business entity (pure public type), (ii) those involving both public and private entities in the project entity (public/private mixture type), and (iii) private enterprises under regulation (private type).

Depending on the characteristics of the infrastructure project, it is decided which of these types the business entity will take. This is shown graphically in Figure 3.1.

Figure 3.1: Typology of an Infrastructure Business Entity



Source: Authors.

3.1.2.1 Pure Public Type

Certain infrastructure is indispensable for society, but it is practically impossible to collect usage fees from users for this type of infrastructure. Instead of usage fees, public institutions such as the government and local governments use tax revenues collected from citizens.

Ordinary roads and river disaster prevention facilities such as levees are representative of this type of infrastructure and are also called pure public goods. We will call this type the "pure public type."

3.1.2.2 Public/Private Mixture Type

Since infrastructure other than pure public goods can identify users and collect usage fees, it can be established as a private enterprise. In reality, for various reasons, public institutions such as governments will participate in the project entity. They can be divided into several types as follows, depending on the difference in how the public and private sectors engage in the project.

First, there are cases in which the scale of the project is extremely huge, making it difficult to realize with private funding capacity, even if sufficient business profit can be expected in the future. By investment by the country or others, or by debt guarantee to the business entity, financing can be made possible to establish the business. Many projects done through public corporation entities, such as the Tōmei Expressway and the Tōkaidō Shinkansen, are this type. The point that the public bears the burden or subsidizes the initial investment of the average cost reduction type project is the same as in the "initially subsidized type" described below. However, since it is characterized by the fact that it needs more procurement than private companies can raise funds for, making it necessary to raise funds from the public, we will discuss this as the "huge business type" below.

Next is the profitability of the business. There are many cases in which infrastructure projects exist to respond to needs and to provide socially fair services, which should be executed from the viewpoint of social welfare and cannot be expected to generate profit. A couple of examples are bridges to remote islands and railroads in depopulated areas. These are to support local communities and can be called the "community-supported type."

Infrastructure generally functions over a long period of time. Even if there is not enough demand at the beginning of the operation, as the business matures in many cases, demand increases, business income increases, and average cost decreases. In such an average cost reduction type business, there are some cases of public enterprises being the business entity, in which the public pays part or all of the initial investment and privatization is planned after the business management gets on track. In the early stage of the project, the public may subsidize a private enterprise that is the business entity. We will call such a type the "initially subsidized type."

3.1.2.3 Private Type

There are many infrastructure projects where the government does not join the project entity. Services there are supplied through market mechanisms. However, from the viewpoint of public nature and impartiality as shown below, or from the viewpoint of strengthening the competitiveness of the country and region, if necessary, the administrative organization in charge of the operation of the project (e.g., the Ministry of Land, Infrastructure, Transport, and Tourism railway department) may establish regulations or provide policy support. Administrative organizations that make such regulations are sometimes called regulatory agencies.

Among these regulations, the first is the "supply control type" regulation to eliminate adverse effects of natural monopolies. An industry with a large initial investment (infrastructure being the representative example) becomes a monopoly of one company in any region, leaving it to free competition. (This is called a natural monopoly.) There is a possibility that the public benefit may be impaired when the company pursues excess profit and sets excessively high fees, or conversely when the company quits providing the service because it is not profitable. Therefore, based on this idea, the administration regulates in terms of market entry and exit and fees.

The second is the "competitive adjustment type" regulation. For example, in the case of two railway lines competing in land transportation, leaving it to free competition will result in catastrophic service competition, which may result in social loss. For this reason, there are cases where entry by a plurality of companies is restricted or adjustments are made to remove unfair competition conditions between them. (This is called equal footing.)

The third one is the "regional strategy type" regulation. If the capacity of the infrastructure greatly affects the country's international competitiveness or regional competition such as regional airports, like international hub airports and international hub ports, there are cases in which the public will politically support infrastructure development and functional enhancements.

A facility that does not require such regulation and is supplied exclusively based on market function can be called the pure private type.

One example could be large-scale leisure facilities, but they differ from the focus of this book, infrastructure as a social infrastructure, in terms of their lack of public nature and the like.

Public organizations such as the national government and municipalities have traditionally been deeply involved in the construction and operation of ports and airports. These days, in the field of international transport, competition between bases has become intense. There is a global tendency to privatize the infrastructure management entity of international transportation centering on developed countries, in order to increase the management efficiency and competitiveness of the infrastructure. Assuming that such movements will progress more and more in the future, in this book we intentionally classify international hub airports and international hub ports as "private type."

Needless to say, not all types of infrastructure can be clearly categorized in the terms discussed above. Also, one infrastructure case may have multiple types of features. In addition, even with the same infrastructure, it may be appropriate to reclassify from one type to another due to changes in functions and the business environment required by society. For example, as mentioned earlier, it was appropriate to classify the international hub airport as the "initially subsidized type" or "huge enterprise type." It was a project that was difficult to establish as a private enterprise in the past, including land acquisition. However, it has become necessary to improve management efficiency to enhance the international competitiveness between hub airports. In many big airports, they introduced privatization of the management entity, concessions, etc., and their types have been changed to the "regional strategy type" within the "private type."

3.2 Pure Public Type

3.2.1 Features

In our society, consumers pay suppliers to obtain the goods and services they need. The business of the supplier is established by that income. Even in the infrastructure business, railways were established as a business due to the toll income from users, and the water supply business was established as a business based on the water fees paid according to the amount of water used.

However, it is impossible technically and socio-economically to collect road usage fees individually from each traffic passenger and each car on general roads, for example. That is, general roads, due to their characteristics, currently allow free riders. This is the reason why general roads are said to have "non-excludability." It is impossible to conduct businesses that cannot collect usage fees as private businesses, and they will be implemented only as a public project that relies on tax revenue. The biggest reason why infrastructure projects such as general roads must be conducted as public works is such non-excludability.

Another reason that general roads and river banks should be implemented as public projects is that no one competes to receive services from that infrastructure. As long as there is no traffic congestion, a large number of users can use the same road at the same time without lowering the service level. Similarly, river levees indiscriminately protect everyone in the flood area from flooding at the same time. If you impose a usage fee for using infrastructure that has such characteristics (which in many cases is not realistic), the usage will decrease and the benefits that society would obtain from its use will also decrease. This means that social loss occurs. This loss is sometimes called "dead weight loss." In this way, we think that non-competitive infrastructure projects for consumption should use public resources, rather than being run as private businesses that collect usage fees.

Goods and services with such non-exclusion and non-competition are called "pure public goods." These types of infrastructure projects are implemented by public sector as public works with the main financial source being tax.

3.2.2 Business Entity

Pure public type infrastructure, that is, infrastructure constructed and managed only by the public sector using public money, is legally categorized as "public property." The organizations that can build this type of infrastructure are clearly defined based on the public property management law.

Infrastructure projects for which public sector actors are the business entities are called "public works." We observe several types of these. There are projects that are relatively large and have wide-ranging influence, which are generally directly controlled by the central government. There are also projects that are implemented by local governments receiving subsidies and other types of support from the central government or higher levels of local government. There are projects that are relatively small and are implemented by local governments with their own funds.

In the cases of the projects directly controlled by the central government, ministries such as the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) and the Ministry of Agriculture, Forestry, and Fisheries (MAFF) establish comprehensive plans for the infrastructure projects under their jurisdiction, determine the priorities of the projects, and manage the overall budget. For individual projects, local offices of the central government and their execution organizations throughout the country (e.g., national highway offices, river offices, port offices of MLIT, agricultural irrigation and fishery offices of MAFF, land improvement construction office, reclamation construction office of MAFF) promote the actual business. In Japan, the governmental institutions involved in infrastructure projects as business entities are sometimes called “executive ministries.” In supplementary projects and regional independent projects, the appropriate departments in prefectures, municipalities, and so on formulate plans and budgets, manage, and operate.

Administrative organizations have high creditworthiness and high risk-bearing ability because they have a background of tax collection rights of the government. Therefore, in terms of financing, in general, they have greater power than private enterprises. Meanwhile, their organizational objectives and their project objectives are strictly stipulated by laws and regulations and are not suitable for diversifying project objectives.

Unlike private enterprises, an administrative agency has to conduct infrastructure projects under various restrictions. Particular features of public works that differ from private sector businesses are (i) congressional approval, (ii) application of public accounting, and (iii) public property management. Funds for public works are mainly procured through taxes, issuance of public bonds, and subsidies from, for example, the central government.

3.2.2.1 Congressional Approval

The activities of administrative agencies are based on the annual budget. After the budget is adjusted within the administration, it will come into force after being deliberated on and approved by Congress.

The right to compile the national budget resides in the Cabinet (Article 7 of the Constitution). The Ministry of Finance prepares a budget and submits it to the Diet after a Cabinet decision (Article 21 of the Financial Act).

Local governments’ budget proposal rights and executive powers are owned by the heads of the local governments (Article 149 of the Local Autonomy Law). Regional autonomy law does not permit parliamentarians to submit budget proposals (Article 112). Also, ordinances with the budget must not be enacted or amended until budget measures are properly taken (Article 222 of the same).

In this way, in the administrative budget, the budgeting process and the responsible entities are strictly stipulated. The public budget is also fixed for each fiscal year through this process.

3.2.2.2 Application of Public Accounting

The business entity must perform inventory management (accounting management, fund management) in the construction and operation of infrastructure. The rules to be followed are different between public institutions and private companies. The former are based on public accounting (government accounting) and the latter are based on corporate accounting.

Generally, public accounting consists of single-entry bookkeeping, cash basis accounting, and a one-year budget; corporate accounting is double-entry bookkeeping, accrual accounting, and multiple-year appropriation. The design philosophies of public accounting and corporate accounting are quite different, and this difference affects the operation of the infrastructure business.

The purpose of public accounting is to clarify the use of taxes collected and to prove that they have been appropriately executed. Cash basis accounting is important for governmental organizations' accountability. To prove that tax revenue (revenue) and necessary expenditures (expenditures) are balanced yearly, governments record deposits and withdrawals by the actual entering and exiting of cash, and they are totaled in fiscal year units. There, emphasis is placed on the balance of income and expenditures in the relevant fiscal year, and single-entry bookkeeping (deposit/withdrawal record) is mainly used for management. Expenditure is strictly based on the budget; arbitrary expenditures outside the budget are illegal.

Since public accounting is carried out on a cash basis and uses the single-year fiscal policy, there is no mechanism to accumulate expenses for future repair and updates (depreciation in corporate accounting). Repair and update expenses are budgeted and enforced every time it is required for the year.

3.2.2.3 Public Property Management

Infrastructure that an administrative agency owns or operates is treated as public property. Public property is the opposite of private property; it is tangible goods provided directly for public use by administrative entities such as national and local governments. Specifically, roads, rivers, harbors, coasts, parks, government buildings, public hospitals, school buildings, and the like are regarded as being public property.

Artificial and natural objects are also included in this type of property. Public property that is publicly used by officials is called "public property," and other public things that are managed by public offices and used for public use are sometimes called "property for public use."

The management of public property is strictly stipulated by public property management laws. Pure public infrastructure is constructed and operated based on public property management laws. Administrative responsibilities and the tax burden are important matters to be noted.

In the event of damages to people due to a defect in the installation and management of the public property, the country or local government that is the administrator of the public property is unilaterally liable for compensation (Articles 2 and 3 of the State Liability Law). The responsibility for the management of public property is extremely heavy and it is an important item that must be attended to when promoting the utilization of private energies, such as in the case of public–private partnerships (PPPs) or PFIs.

Also, privately owned tangible fixed assets are subject to property tax, but public property is exempted. The border between public and personal property in taxation is partially based on administrative judgment, and the type of the management entity and the manner of usage fees are the major judgment factors.

There are restrictions on the use of the property for public use as well. For example, occupation of these properties (e.g., recreational facilities such as sports facilities like riverbed field baseball games and campgrounds) requires permission from the administrator, and an occupancy fee is generally charged. Also, when a parade is planned on a road or when traffic control is needed for shooting movies, it is necessary to notify the administrator in advance and obtain permission. When burying a gas pipe or the like in the underground space of a general road, it is necessary for the administrator to obtain official approval. Cases where private enterprises can manage public property are limited to the designated manager system based on the Local Autonomy Law.

3.2.2.4 Funding: Tax, Issuance, Subsidies/Grants

The funding source of pure public infrastructure projects is mainly tax revenue and issuance of public bonds. In cases where local governments are the project entity, subsidies and contributions from higher organizations may be allocated in some cases.

As infrastructure projects require a huge initial investment, ensuring their financial resources continues to be a major issue in every country. In Japan, for a large amount of infrastructure under construction in the second half of the 20th century, in addition to expenditures from general resources, major funding roles were played by securing specific financial resources (earmarked taxes), utilization of Fiscal Investment and Loan Program (FILP) investments (discussed below, a kind of Japanese government bond), and issuance of construction bonds.

Specific financial resources are the revenues based on taxes whose usage is restricted (earmarked taxes) and which are often managed by special accounts separate from ordinary taxes. For example, the revenue of the Japanese government from the restoration tax can be used only for the reconstruction of areas damaged by the Great East Japan Earthquake. In relation to infrastructure development, income from gasoline taxes had long been used for road maintenance purposes. However, most of the national taxes now convert to ordinary tax, and a small number of earmarked taxes remain only in the area of local taxes. For example, urban planned taxes (local taxes) are allocated to urban planning projects and land subsection reorganization projects from the viewpoint of the beneficiary burden.

FILP investment is investments and loans by governmental organizations to entities like special public corporations. Previously, huge loans were made with postal savings, post office insurance, and pension funds as resources, but the system has been changed, and now it is mainly based on the issuance of government bonds. The relevant government bonds are called FILP bonds. The term construction government bonds is also often used. The origin of the name was that that bond was issued for the purpose of raising funds for public works.

Also, various public subsidies are prepared for infrastructure construction and operation. Such assistance is applied in the following cases: when local governments and private enterprises with limited financing capabilities deal with infrastructure improvement; when the planned infrastructure is widely recognized to increase public interest; and when it seems apparent that with proper assistance, private enterprises will be able to implement infrastructure that leads to socially meaningful results. At the time of the appraisal for assistance, the government's policy intention, such as the promotion of specific industries, may be reflected. Systems such as subsidies are often set according to policy intentions.

However, from the viewpoint of local autonomy, the average local tax revenue of governments is about 30% of their total income, and the other 70% is granted from the central government such as local allocation tax subsidies and national treasure subsidies. This arrangement can be viewed critically as allowing for only "30% autonomy" for local governments.

The level of public utility fees is set by the administrator of the public property. One example is a case where private companies use riverbed space for recreational facilities (e.g., golf courses, campgrounds). This rental income will be devoted to maintenance and management of the infrastructure.

3.2.3 Subjects Viewed by Businesses

3.2.3.1 River Projects

Rivers are representative natural public goods. River improvement adds artificiality to natural public goods for the purposes of flood control, water use, and environmental conservation. The subject of the project is decided based on the river law, which is a public property management law. For rivers under the river law, private enterprises cannot freely do business such as renovation. The business entity is decided by the law in the order of country, prefecture or cabinet designated city, and then municipality.

The top-ranked rivers in Japan are legally termed first-class rivers, and more than 14,000 are designated nationwide by the central government. The first-class rivers are designated and managed by the Minister of Land, Infrastructure, Transport, and Tourism based on the river law. These rivers are generally of a large scale, spanning multiple prefectures or cities designated by ordinance. Regarding certain parts of these rivers, the central government can delegate management of the river to the prefectural governors or the head of a government ordinance designated city.

Additionally, more than 7,000 second-class rivers are designated nationwide. Second-class rivers are selected and designated by prefectural governors. During the designation process, governors are to hear the opinions of the relevant municipal mayors. The municipal mayor has to ask for the parliament to decide to accept his or her opinion before answering the governor. In this way, designation of first-class rivers and second-class rivers based on the river law is very strict.

Furthermore, there are non-legal rivers (rivers that are neither first-class nor second-class). Those municipal mayors who judge certain rivers to have a high need for public management are governing them using the rule of the second-class river provision. These are called provisional-class rivers, and there are more than 14,000 of them nationwide.

Non-legal rivers that are not provisional rivers are called ordinary rivers. Ordinary rivers are not subject to the application of the river law. The municipalities regulate and manage them by establishing ordinances as necessary. The well-known ordinary rivers include the Takase River in Kyoto City and Nikaryō-Yōsui in Kawasaki City.

3.2.3.2 Roads

Roads are representative artificial public objects, and there are various kinds. Most of them in Japan are the roads prescribed by the Road Law, which is a public property management law. The Road Law governs high-speed national automobile highways, general national roads, prefectural roads, and municipal roads. The law also stipulates the business entity for each type and regulation. Though this section discusses pure public type infrastructure, in our classification the toll road will be classified as the public–private mixture type. The term “road” here includes traffic safety facilities and traffic information facilities.

The general national roads are the roads specified by the Cabinet Order based on the Road Law. The Cabinet Orders are the orders established by the Cabinet and having legal power. It can be said that this type of road is authorized by the central government as national trunk lines in conformity with some conditions such as connecting the major cities. The national roads have designated sections and non-designated sections; the former are managed by the central government (the Regional Development Bureau, Hokkaidō Development Bureau, and Cabinet Office of the Okinawa General Secretariat), and the latter are managed by the prefectures and the cabinet designated cities.

The prefectural roads are the roads that prefectural governors decided through parliamentary decision. They are managed by the prefectures. The prefectural roads of one prefecture sometimes pass through an area other than its own or the area of cities designated by ordinance. Regarding such cases, the Road Law stipulates procedures for consultation with relevant local governments (prefectures or cities). The municipal roads are the roads where the route is decided by the parliament of municipalities, and the municipality is the administrator.

There are major provincial roads designated by the Minister of Land, Infrastructure, and Transport as prefectural roads and municipal roads. These roads are judged to be of high social importance because they connect two or more local public entities or provide at least one of the starting points to a railway station or highway interchange, port, airport, etc. The major provincial roads are not national roads, but the central government can assist administrators of these roads with some maintenance and maintenance costs.

3.2.3.3 Port Business

There are two types of harbors in Japan. One is a type of public good managed by administrative agencies based on the Port Law, and the other is based on the port, fishing port, and fishery maintenance law.

The former is under the jurisdiction of MLIT. The latter is under the jurisdiction of MAFF and is assumed to be used mainly by the fishery industry. We will describe the ports defined by the Port Law, which is infrastructure for more general use.

Under the Port Law, it is stipulated that the port authority or the local public organization will serve as the manager, or the port administrator. In other words, unlike with roads and rivers, the country is not lawfully required to become a port administrator. A port office is an organization aimed at port management established by a local public organization alone or jointly with multiple organizations.

Although the modernization and centralization started in Japan in the 19th century, ports in the country had been built and managed under various laws, ordinances, etc. for a long time because there had been no enactment of a basic law. After World War II, the new Constitution of Japan, enforced in 1946, states that in principle all the actions by administrative organizations should be taken under the law. The absence of the basic law was no longer permitted, and the Port Law was enacted in 1950. In doing so, the Allied command that occupied Japan at that time gave the utmost local autonomy rights to the management and operation of ports and decided to keep the government's supervision and regulation to the minimum necessary. The Japanese government had considered that local governments might be port managers, but the port authority concept was inserted by the Allied forces, who had images of the port authorities in the Western world. Currently in Japan, Niihama Port (Ehime Prefecture) is the only port that is administrated by a port authority.

In recent years, the Port Law was revised regarding the management and operation of port facilities to improve the competitiveness of ports by maximizing the management capabilities of the private sector. That amendment had a large effect. At the international strategic ports (Keihin Port, Hanshin Port) and international base ports (18 nationwide), it became possible to set up a "port management company" that centrally manages the operation of ports. The port administrator maintains quays and the like and lends them to the port management company. The port management company maintains gantry cranes, etc. and conducts sales activities strategically with shippers and shipping companies, as well as collecting tolls. This system has already been introduced at Keihin Harbor and Nagoya Port.

3.2.3.4 Urban Parks, Etc.

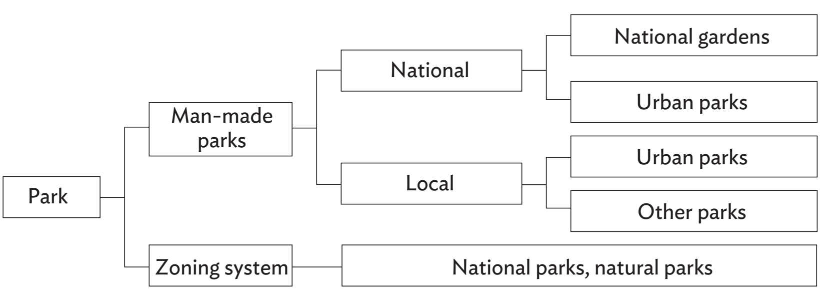
Urban parks are also representative public property. Urban parks are artificial parks whose beneficiary areas are geographically narrower and limited to the cities compared to national parks, which are natural parks in the spacious countryside. For this reason, the entity promoting urban park projects is generally a local government (prefectures or municipalities). Construction and management of urban parks was limited to local public entities and their outer entities for long time.

In recent years, many local governments have introduced a designated manager system, and private companies and non-profit organizations increasingly take part in the management of urban parks. The designated administrator system is an institutional system in which local governments can select a certain organization as a comprehensive administrator of public property. The candidate organization must be selected according to the procedures that the local government establishes, and the final approval of Congress is necessary. In the case where the designated manager manages toll infrastructure and fee income is generated, the designated manager can take it as their own revenue within the range of an amount agreed with the municipality, the consigner. It is said that this system has the merit of promoting the efficiency of infrastructure management operation.

In addition to urban parks, other parks designated and managed by the government (Ministry of the Environment) include 32 national parks (districts with national landscapes, etc.) and some national nature parks. The latter are the former imperial gardens, including the Imperial Gaien and Shinjuku Gyoen, which were opened to the public after the war. Other than these parks, we have in Japan 57 sub-national parks (designated by the central government and managed by local governments) and 315 prefectural natural parks (designated by prefectural governors based on the ordinance, and managed by prefectural offices) (see Figure 3.2).

Looking to the world, the management entities of urban parks are varied. Central Park in New York is owned by New York City Hall but managed by the non-profit organization Central Park Conservancy,

Figure 3.2: Typology of Parks



Source: Ministry of Land, Infrastructure, Transport, and Tourism.

founded in 1980. The group raises 85% of Central Park's annual budget of $20 million from donations and so on, handles the expenses for repair and administration, and pays 75% of the park staff's wages. British parks like London's Hyde Park and Regent's Park were originally owned by the British royal family and are now open to the public. The administrator is a government agency called The Royal Parks.

3.2.3.5 Future Trends

The pure public type infrastructure is characterized by difficulty in identifying users and usage fees being impossible or remarkably difficult to collect, so administrative organizations have no way other than using tax revenues or issuing public bonds. However, from the principle of the beneficiary's burden, it is inherently desirable for the user to bear the burden. Along with the progress of information and communication technology (ICT) in recent years, it is technologically possible to grasp the travel history of a car, for example. It is becoming possible to identify users in this way. It is no longer a technical problem to collect congestion taxes for road use at times of heavy congestion. In addition, hazard maps are being released, and it is also possible to recognize and share the beneficiary scope of disaster protection by river banks.

For these reasons, it is conceivable that a beneficiary burden system could be introduced into some of the pure public type infrastructure in the future.

3.3 Public–Private Mixture Type

3.3.1 Overview

3.3.1.1 The Reason We Need the Public/Private Mixture Type

It is preferable that fee-collectable infrastructure projects are entrusted to the private sector as much as possible because it will lead to the minimization of public burden and improvement in management efficiency.

On the other hand, the fact remains that some infrastructure such as airports and ports on remote islands should be constructed as the basis for life and the economy in isolated areas. In these cases, projects that require massive funding cannot be completed without governmental aid, even if the users of the infrastructure are identifiable (which means this infrastructure can be fee-collectable).

For this reason, many operating entities have been devised with both public and private features. In some cases, a public sector actor invests in or sends officers to a stock company. In other cases, it establishes a new public organization with a lot of private features and management flexibility.

Such operating entities in between public and private are established when fee-collectable projects, which are supposed to be run by the private sector, are unable to be run in that way in practice due to low profitability and a funding problem. The public sector can contribute to funding using its high credibility and stabilize the management. Here we call this type of project the public/private mixture type.

In the previous section, we outlined operating entities with the pure public type. Now, we will discuss the characteristics of private projects compared to those with the pure public type, and then we will offer an example of each public/private mixture type.

3.3.1.2 The Characteristics of Private Projects

Establishment and Scope of Business

Most private companies can be established when they meet certain conditions like having enough capital stock. Based on business accounting practices, real assets are depreciable, unlike the case of governmental organizations. Tax and public dues are not exempted. The shareholder meeting is the highest decision-making entity. As the shareholders are responsible within the capital funds they contribute, the risk-bearing capacity of a private company as an operating entity is generally small and limited compared with public organizations. Additionally, their credibility is low in comparison with organizations run by the government, which has the right for taxation.

A proportion of the profit generated in a private project is paid as a dividend to shareholders. They usually expect dividend maximization in the short term. When a project requires the management of large fixed assets like infrastructure projects, the operating entity needs the shareholders' understanding of the investment plan and maintenance measures because they need to pay the debt of the initial investment and accumulate funds for routine maintenance, future updates, or expansion. They can make decisions at shareholder meetings to amend the articles of incorporation that define the scope of the business and expand or diversify their business. This means that private companies are more flexible in their mission-setting compared with governmental organizations.

Meanwhile, a third-sector company is a private company whose shareholders include the public sector. It is regarded as a combination of the public sector (the first sector) and the private sector (the second sector). Administrative agencies join as shareholders of a third-sector company that runs highly public infrastructure projects. They support its operation so that they can maximize the local social welfare instead of maximizing dividends.

Application of Corporate Accounting

Corporate accounting is designed to help enable an appropriate profit distribution on the premise of the entity's permanence. The accounting has to provide a clear picture of the corporation's financial condition and clues about its management forecast to stakeholders. The financial statements need to indicate existing claims and obligations (unrealized gains and losses) as well as cash transactions. Double-entry bookkeeping, accrual accounting, and multi-fiscal accounting are very important in corporate accounting.

Under accrual accounting, credit obligations are reported when they occur instead of when payment is made. The seller can record sales as soon as it provides products based on the contract and issues an invoice at the time when the purchaser is obligated to pay. Corporate accounting sees changes in claims as revenue even before the money is received. They can book unrealized gains and losses so that they can better explain their financial condition.

Under accrual accounting, thus, it is important to specify when gains and losses occur. Without doing that, it would be hard to explain the financial condition appropriately to shareholders and conduct tax procedures due to arbitrary accounting or income manipulation. Companies have to observe the accounting discipline, and their accounting reports have to obey the accounting and tax regulations and be audited.

Companies raise funding from issuing stocks and bonds, as well as borrowing from banks. These are not sales revenue but simply asset changes. In order to record borrowing as debt, both the income statement (a report of annual revenues and expenses) and balance sheet (a report of assets and liabilities at the end of the fiscal year) are necessary. This is why private companies should use the double-entry bookkeeping system.

Depreciation

One of the biggest differences between public and corporate accounting in infrastructure projects is depreciation.

Depreciation is an accounting method of allocating the cost of building a physical facility over all the years in its useful life, not in the years of real spending. For example, when a company constructs a ¥10 billion rail facility with a useful life of 50 years, it can calculate depreciation at ¥200 million on the income statement for 50 years even though it pays ¥10 billion in cash in the first year. It is a conceptional cost based on the matching principle, not associated with real cash flow. The construction cost of ¥10 billion is recorded on the balance sheet as a change in assets, which means i) increase in borrowing or depletion of cash assets and ii) increase in fixed assets, both of which balance out.

If we use the cash basis accounting rule for initial investment of infrastructure projects, it will cause a big loss in the years of real spending and we will see extremely high revenue after the infrastructure is placed in service because the maintenance cost is lower than the construction cost. If the profit is high, the shareholders will demand a high dividend and the tax office will charge a high tax. However, when a private sector actor invests in construction using borrowing, a repayment source is always necessary because repayment continues for a long time. Considering the maintenance cost and future update costs, it is not realistic to pay tax and to answer to shareholders' demands for profit distribution, even though the revenue is high after the infrastructure is placed in service.

For this reason, they treat the initial investment as an annual expense account by allocating it over the useful life so that it is not taxable or distributed. This enables them to secure a repayment source for the borrowed money and to accumulate funds for future updates. This helps maintain facilities, which are essential parts of infrastructure projects, and distribute profits properly.

The idea of depreciation was born in Britain in the 19th century and developed in the United States (US). In both places, industries that provide service by operating huge fixed assets, such as the railway and steel industries, were established and developed earlier than elsewhere in the world. These industries have a big gap between when costs occur (especially initial investment) and when gains occur (especially charges for use), so there was a growing recognition that cash accounting was improper. As a result of looking for new accounting rules, especially for handling fixed assets, the depreciation method was devised.

After the process industry (heavy-equipment type industry) appeared, many modern management approaches were invented. One management scholar pointed out that it was mainly the rail operation that developed almost all the modern accounting from the 1850s to the 1860s.

One of the depreciation methods is called the straight-line method, which calculates annual costs by dividing total costs by the useful life. The other way is the declining balance method, where the annual cost declines at a certain rate. It is an accounting principle that only recognizes the expenses that contributed to income in the accounting period as the cost.

3.3.2 Various Operating Bodies

3.3.2.1 Public Organizations Like Special Public Corporations

Special public corporations are a typical example of the public/private mixture type. They are public corporations or special banks established by decree with a goal of assuming some of the roles of administrative execution. There have been many corporations that have constructed and operated infrastructure, such as the Japan Highway Public Corporation, Metropolitan Expressway Public Corporation, Japanese National Railways, New Tokyo International Airport Authority, and Nippon Telegraph and Telephone Public Corporation. These entities are allowed to borrow money and raise loans on their own, guaranteed by the government if approved by parliament. They can also receive government investment and loans for funding and be exempted from corporate taxes and fixed assets taxes. Their business plan requires annual approval from parliament.

In this way, these corporations have made a major contribution especially to the promotion of constructing infrastructure, bolstered by the government's credit strength and their high fund-raising capability. However, they are not appropriate for diversification of business because the purpose of these organizations is strictly defined based on how they are established.

Examples can be seen overseas as well. France has Établissement Public, the government's external entity in charge of public undertakings such as Régie Autonome des Transports Parisiens and Réseau Ferré de France.

Special public corporations used to manage both the construction and operation of infrastructure, but these days they tend to focus on funding and asset holding, as many public corporations in the world have privatized operations to promote management efficiency. Public corporations in Japan have also privatized operations like expressway companies as we will discuss in Chapter 4. In parallel with this, more incorporated administrative agencies such as the Japan Railway Construction, Transport, and Technology Agency; Japan Water Agency; Urban Renaissance Agency; and Japan Expressway Holding and Debt Repayment Agency have been established as main players in the construction of facilities, funding, and ownership.

The incorporated administrative agencies are executive arms with basic laws but are financially independent based on their business income. In contrast to conventional special public corporations, their funding is not guaranteed by the government in principle, they are obliged to pay taxes, and the employees are not public employees. All these differences are important to promote management efficiency in today's business circumstance where operation and maintenance become more important.

3.3.2.2 Public Enterprises

Public enterprises undertake infrastructure projects of local governments such as water and sewerage as well as transportation. They are established by local governments based on the Local Finance Act and are non-juridical affiliated agencies of local governments, which in reality are a part of local government. They generally charge service fees unlike pure public infrastructure projects. The business income is applied to operation costs, so they have a special account apart from the general account. The waterworks bureau and transportation authority of local governments are examples.

Sometimes an independent operating entity of an infrastructure project is sponsored to be established by local governments. One example is a local road public corporation, and there are over 30 of them in Japan. Although they are very close to local governments because they can be sponsored only by local governments, they can earn revenue from toll roads. They are financially independent basically, but are required to recognize their revenue as reserves unlike stock companies.

3.3.2.3 Third-Sector Companies

The third sector refers to organizations that are neither public sector (first sector) nor private sector (second sector). In Japan it usually refers to corporations jointly established by the public and private sectors. Most of them are stock companies. Some shareholders are local governments and/or other public sector entities. These "public" shareholders are expected to lead the third sector to maintain the public aspects of the projects in many ways by enabling long-term and stable management instead of excessive profit distribution.

Japan has many third-sector companies in the field of local transportation. Although operating transportation in regions with low transport density and unlikely revenue is not very attractive for private companies, third-sector companies are established to meet the community's strong demand for public transport services. Facing difficulties in profit earning, most of these companies rationalize more of the railway service, hold local events, and operate kiosks and travel agencies to increase revenue.

Even in urban areas, many third-sector companies have been established to support local industries and lives by supplying public services like transportation for reasonable fees. For example, the shareholders of the Tama Toshi Monorail Line connecting the north and south of the western part of Tokyo include the Tokyo Metropolitan government, Seibu Railway, and Mizuho Bank. The Nagoya Rinkai Railway that connects the center of Nagoya and port of Nagoya was funded by Nagoya City Council, Aichi Prefecture, Japan Rail (JR) Tōkai, Chubu Electric Power Company, and others.

3.3.2.4 Special Companies Owned by the Government

Most of the third-sector companies are established according to the Companies Act, but when the project is highly public and large, a new operating entity is established according to special laws that apply to the establishment of such entities.

Examples are the Narita International Airport Corporation (established according to the Narita International Airport Corporation Act), Tokyo Metro Corporation (Tokyo Metro Corporation Act), and the three expressway companies in Japan (Expressway Company Act). These organizations are called special companies. They take over the operation of former special public corporations such as the New Tokyo International Airport Authority, Teito Rapid Transit Authority, and Japan Highway Public Corporation, sometimes separating the holding of facilities and operation and management. Many take the form of stock companies, with a view to future private capital intake.

There are some practically public-owned organizations other than special public corporations established according to basic laws. The Trans-Tokyo Bay Highway Corporation, which operates and manages Tokyo Bay Aqua-line Highway, is a third-sector organization, for example. This company looks as though it is owned mainly by private companies, but its largest shareholder, the East Nippon Expressway Company, with a share of 33.3%, is owned only by the Finance Minister, and its other main shareholders are local governments including Chiba Prefecture, Kanagawa Prefecture, and the Tokyo metropolitan government. There are some private companies such as Mizuho Bank and MUFG Bank that own stocks, but their share is around 1% each. JR Hokkaidō and JR Shikoku have not been listed yet, unlike JR East, JR Central, JR West, and JR Kyūshū. They are virtually national companies because they are owned only by an incorporated administrative agency called Japan Railway Construction, Transport, and Technology Agency. They are more public corporations than private companies.

3.3.3 Large Investment Type

3.3.3.1 Characteristics

Infrastructure projects such as roads, railways, ports, airports, and dams are generally enormous, and they are likely to require billions, or hundreds of billions of yen in initial investment for construction (including site acquisition, material procurement, labor, design, and supervision).

It usually takes more than a few years for the construction of facilities during which the operating entity makes no revenue but must spend heavily, so it needs considerable capital in the early stages. For this reason, the entities need adequate capital and fund-raising capability, especially in large-scale projects, which we will call the large investment type.

From the viewpoint of creditworthiness, the government has more ability to fund-raise than any private sector entity. In most large investment type infrastructure projects, operating entities are established that have fund-raising and management capability. Like the Trans-Tokyo Bay Highway Corporation, many companies can inject a lot of funding, with more than half of the capital coming from national or local governments despite being stock companies.

These entities borrow from the private sector to raise money, but in many cases financial institutions establish syndicates to hedge their risk as described later.

3.3.3.2 Operating Bodies

Taking advantage of national credibility, many public institutions such as the Honshū–Shikoku Bridge Authority and Japan Railway Construction, Transport, and Technology Agency (formerly the Japan Railway Construction Public Corporation) are established for infrastructure business operation. They used to comprehensively construct and manage infrastructure, but now they tend to focus on funding and holding of facilities after reviewing their functions.

3.3.3.3 Funding

The operating entities raise funds in many ways. Entities such as special public corporations established by governments are designed much more flexibly than governments in terms of fund-raising. The following are the dominant approaches.

Bond Issuance

The operating entities can issue bonds. Some are issued through the bond markets, and others are issued as private placement bonds. In many cases, private placement bonds are taken by local governments that will enjoy benefits from the infrastructure projects. When in a bond market, entities are required to explain their business and vision to investors, and to practice highly transparent management.

Syndicated Loans

When an operating entity is asking for a large loan, financial institutions sometimes establish a syndicate to hedge their risk. The loan, called a syndicated loan, is made on equal terms and is coordinated by an arranger.

Government-Guaranteed Debts

The government can guarantee the bonds and borrowing of public corporations. There are two types of fund-raising: government-guaranteed bonds and borrowing. Guarantee limits are determined by parliament for each case.

Many companies such as the Japan Highway Public Corporation, Metropolitan Expressway Public Corporation, and New Tokyo International Airport Authority issued government-guaranteed bonds. These bonds differ from general corporate bonds in that banks as well as stock companies can underwrite them. Today, the Japan Expressway Holding and Debt Repayment Agency, which owns expressways in Japan, issues 20- or 30-year bonds.

Non-Government-Guaranteed Debts

There is also borrowing by the private sector that is not guaranteed by the government. Public corporations can borrow more than the limit of the government guarantee. In such cases, a public corporation has to obtain approval for borrowing by the relevant minister.

Government Investment and Loans

Loans can be made from Fiscal Investment and Loan Program bonds (FILP bonds) to operating entities. This requires parliament's approval as it is like a general account. These loans used to be funded with postal savings, postal life insurance, and national pension funds until reform of the Fiscal Investment and Loan Program in 2002. FILP bonds and construction bonds are the only capital today that is issued by the government for a specific use.

Development Finance Such as World Bank and Asian Development Bank

Many developing countries with small amounts of capital are not able to raise enough capital domestically for the construction of needed infrastructure. In these cases, multilateral development banks assume a key role in finance.

Japan built a network of expressways and shinkansen with money borrowed from the World Bank from the 1950s to the 1960s. Public corporations such as Japanese National Railways, the Japan Highway Public Corporation, and the Japan Development Bank obtained the loan, and of course the borrowing was guaranteed by the government.

3.3.3.4 Examples of Fundraising in Large Projects

Fundraising for the Meishin Expressway and Others

Much of the infrastructure that underpinned Japan's rapid economic growth was constructed having been financed by the World Bank. Despite its potential for growth, Japan had to borrow from overseas to complete large projects due to a lack of capital at that time.

The first cases of World Bank finance were massive thermal power plants in Kansai, Kyūshū, and Chūbu in 1953. The electric companies borrowed through the Japan Development Bank. The World Bank financed only power plants and large-scale factories in the 1950s, but it started financing infrastructure in the 1960s. The Japan Highway Public Corporation was established before the construction of the Meishin Expressway, and they financed 30% of the construction cost from the World Bank. That borrowing was guaranteed by the Japanese government.

The World Bank financed 31 projects in Japan by 1966. The amount of money borrowed ran as high as $863 million, which Japan repaid in 1990.

Fundraising for the Honshū–Shikoku Bridge Authority

The Honshū–Shikoku Bridge Authority is a government-funded special public corporation established according to the Honshū–Shikoku Bridge Authority Act. Article 1 of the act defined the purpose of the establishment as the facilitation of transport between mainland Japan and Shikoku, balanced economic development by comprehensive and efficient construction, and management of the toll road and railway on the Honshū–Shikoku Bridge.

This entity has six types of underlying assets: governmental funding, the assumption of liability by fiscal investment and loans, privately placed local bonds, a financial institution's assumption of privately placed bonds, private borrowing, and business income. According to the business report for the 2000 fiscal year, the funds procured were 60% external funds and 40% private funds including its own capital. The high proportion of the private fund compared to other public corporations shows that it received a lot of public financing.

The authority planned to secure profits through toll revenues on three routes: Kōbe–Awaji–Naruto Expressway, Seto–Chūō Expressway, and Nishi-Seto Expressway. However, that public corporation was eventually reformed because its business did not become profitable as planned. Based on the scheme of separating infrastructure ownership and operation, the Japan Expressway Holding and Debt Repayment Agency was established as the owner and the Honshū–Shikoku Bridge Expressway Company was assigned to be the operator. Now that the latter makes operating profits, it is paying liabilities to the lender through the former.

Fundraising of Japan Railway Construction, Transport, and Technology Agency

The Japan Railway Construction, Transport, and Technology Agency (JRTT) was established in 2003 according to the JRTT Act, by integrating the Japan Railway Construction Public Corporation (JRCC) and the Corporation for Advanced Transport and Technology (CATT).

JRCC was a public corporation responsible for the construction of railway lines in Japan including Japanese National Railways. One of the parent organizations of CATT was established as the Shinkansen Holding Corporation when Japanese National Railways was privatized. JRTT is an integration of the two organizations that had been engaged in fund-raising and ownership of large investment type infrastructure, which are especially difficult for private sector entities.

JRTT fund-raises by issuing bonds, borrowing from the private sector, and so on. Of all capital, 49% comes from private borrowing (37% from syndicate loans and 9% from government-guaranteed bonds), 38% from their own bonds, and 13% from FILP bonds. The proportion of each type of financing in project finance is individually designed depending on the aspects of each project.

Future Trends

Japan's government has recently tended to be involved only in fund-raising and ownership of the facilities in large investment type infrastructure projects. This is ideal for infrastructure projects in an economically liberal country, consistent with the principle that the private sector should do what it can on its own.

In addition, these days private sector entities seek more investment opportunities, given the comparatively ample capital. If there is a great demand in a huge project, which was supposed to be financed against sovereign credit in the past, a private company can now implement it with their own investment, like Chūō Shinkansen, which JR Tōkai started to construct at the end of 2014.

Infrastructure in Japan in the future will need to meet new social needs other than foreseeable benefits such as the pursuit of efficiency and growing demand. We will see more projects that attempt to improve safety, environment, and landscape in a mature economy. In large cities, these projects will be of the large investment type like the construction to take the Metropolitan Expressway in Nihonbashi underground.

Fund-raising is a great challenge as well when a private company runs this type of project. Public funds are still important when it comes to the large investment type of infrastructure projects.

3.3.4 Regional Support Type

3.3.4.1 Characteristics

Infrastructure projects of the regional support type attract the most interest and face a host of challenges. Many have argued that they should quit large-scale investment or operation of existing facilities with low demand and profitability. This argument will probably continue worldwide as well as in Japan.

One answer is that even if the project is unprofitable, when there are enough external effects and needs as social and economic bases, it has to be implemented one way or another. The question is how to minimize the public burden.

The problem of this type is not only a local one like toll road maintenance in a depopulated area, but also a nationwide one like unprofitable railways. Many railways that had served the community are now on the verge of collapse after the increasing popularity of cars and the declining population decreased their use.

3.3.4.2 Operating Entities

There are various types of operating entities in regional support type infrastructure projects.

Network-type infrastructure including the nationwide network of railways and expressways was constructed by huge nationwide operating entities such as Japan National Railways and the Japan Highway Public Corporation. As we see later in this book, these operating entities used internal subsidization to maintain business in unprofitable regions, and their total business performance was measured by the overall profitability of the country.

However, these entities were separated or privatized. Unprofitable, small local operators were born as third-sector companies all over the country including the companies operating conventional rail parallel to new shinkansen lines. Many entities like local small-scale railway companies operate unprofitable projects by themselves. In these fields, there are many government-run operators such as conventional water suppliers and railway operators.

3.3.4.3 Various Operating Approaches

High profit cannot be expected in this type of project even if it could be charged, and it can be impossible as a pure private project. Many efforts have been made all around the world to keep this type of infrastructure services in existence to maintain regional welfare. Most of them are about exploring ways to minimize the burden while presuming public subsidies will be used for the unprofitable parts. The following are representative examples of approaches.

Internal Subsidization

Internal subsidization is compensation for the losses of unprofitable departments using profits generated in highly profitable sectors. Japanese National Railways supplemented losses in rural railways with revenue from urban commuter rail lines. The Japan Highway Public Corporation used profits from redeemed lines to construct new lines under a methodology called the "nationwide pool system."

Some condemned this pool system, saying that income and expenditures must be balanced in individual routes. They insisted that otherwise, useless infrastructure would continue to be built forever. On the other hand, some rated that methodology as a good way to motivate entities to improve total profitability. This type of argument is unique to fields of public service like infrastructure. In other areas, any private company can internally subsidize areas that are unprofitable but necessary with surplus from profitable projects, as long as shareholders approve.

Regional Assignment

Regional assignment is a geographical separation between the private operation of profitable infrastructure projects and public or some other organization's operation of unprofitable ones. It is usually used for networking infrastructure such as railways, expressways, and toll roads. For example, many unprofitable local rail lines were discontinued and replaced by buses, or the management was transferred to a local third-sector railway company.

The methodology is sometimes criticized as cream skimming because it appears that the private sector is taking over only the profitable parts of the business. However, it is also true that it is rational from a business perspective. The problem remains that many unprofitable third-sector companies have been established and are struggling mainly because they have no income stream as a source of internal subsidization after geographical separation.

Separation of Ownership and Operation

Today, one of the global trends in infrastructure is the separation of ownership and operation; public sector entities own facilities, which generate most of the fixed costs, and private sector entities operate them and make profits. This approach is popular in projects of expressways, railways, ports, and water and sewerage. In the case of Hokuriku Shinkansen, JRTT owns the rail track and JR owns and operates the rolling stocks.

The public possession of infrastructure will make funding easier using the public entity's good credit, reduce fixed assets taxes, and meticulously manage risks of natural disaster that would damage facilities. On the other hand, the infrastructure projects are not depreciable because they are regarded as public properties under public accounting. An enormous amount of money is needed to update the facilities.

Public Subsidization

Public subsidization is sometimes performed for the construction and operation of low-demand infrastructure that is not suitable for private companies' business. It is popular not only in local private railways but also in mass transit in major local cities.

Multiple Projects

The operating entities may run other businesses in parallel with infrastructure operation to promote the total benefit from synergy effects. A good example is real-estate development and retail sales run by railway operators. This is not always easy for the public sector entities, whose missions are defined in their establishment law, whereas it is natural for the private sector.

Concession and Public–Private Partnerships/ Private Finance Initiatives

Concession, public–private partnerships (PPPs), and private finance initiatives (PFIs) are the approaches that were developed in Europe in the 1980s and spread worldwide thereafter.

These approaches do not have the government subsidize fund shortages in the private infrastructure business. Rather, their aim is to maintain public infrastructure services by introducing private management skills to increase financial efficiency or by using private funding to make up fund shortages in public projects. Unlike the cases we have reviewed in this section, the premise is that the project owner is the government. However, we categorize these projects as the regional support type in this book because both are methodologies for providing infrastructure in regions where demand exists but is not large and high profitability is not expected. The key characteristics of this type of project are ownership of facilities and responsibility allocation of fund-raising.

In concession-type infrastructure projects in European countries, some or all of the design, fund-raising, construction, and operation are performed by the private sector. In many cases, the public sector has to assign proper operating entities and conclude a proper contract without preparing a budget. Sometimes the private sector obtains rights and obligations to manage public goods. One could explain that these projects are taken on by the private sector with exclusive rights granted by the government.

In concession projects in Japan, the public sector grants to the private sector the right to operate public facilities for a fee in the long term while they maintain the ownership of the facilities. The construction and updates have not yet been granted to the private sector. Compared to European cases, Japanese cases of this type of arrangement are very limited for now.

PFI is an approach to commission some or all of the design, construction, fund-raising, and operation to the private sector from the public sector. It is considered effective to promote the construction of infrastructure when the public sector, including small local governments, is short of capital and technology.

Based on the facility ownership, PFI is divided into some types, including build–transfer–operate (BTO), build–operate–transfer (BOT), and build–own–operate (BOO). A BTO is an approach where a private sector entity first constructs the facility and operates it after transferring the ownership to a public sector entity. The public sector can maintain its ownership and manage the facility, while the private sector can be exempted from fixed assets taxes without responsibility to manage the facility during the operating period.

In the case of a BOT type, a private sector entity transfers the ownership of the facilities without a charge to a public sector entity after the operation period. This offers many benefits to the public sector, while the private sector is not exempted from fixed assets taxes and has to manage risks like fire insurance as it is responsible for the management of the facilities.

In the case of a BOO type, a private sector entity decides whether it will maintain the ownership of the facilities and keep operating them or restore them to the original state at the end of the operation period. Despite the similarity with BOT, BOO differs in that the ownership is not always transferred to the public sector.

According to the flow of the money, we see there are financially independent types where PFI operators finance projects by fare receipts, purchase of service types where public sector entities buy services from the private sector, and mixed types where private sector entities use both fare receipts and public subsidies. The purchase of service type is a breakthrough idea because it is applicable to pure public projects that are usually free. For instance, Britain introduced PFI to its roads, which are free except for toll bridges and tunnels, under the name of design–build–finance–operate (DBFO). Design–build–operate (DBO) is a form of project where a public sector entity fund-raises and then comprehensively transfers the design, construction, and management to the private sector.

These are just a few examples of private sector initiatives. There are many forms of contracts depending on the characteristics of each project, and many more will be devised in the future.

3.3.4.4 Examples of Various Forms of Projects

We are going to look at some examples to see how the form of well-designed regional support type projects discussed so far is applied practically.

Separation of Ownership and Operation, and Regional Division: Privatization of Japan Highway Public Corporation and New Government-Owned Expressways

Under the policy of separation of infrastructure and operation, Japanese expressways are owned by the Japan Expressway Holding and Debt Repayment Agency (a public agency) and are operated by expressway companies (stock companies).

The expressways are planned by the government from the beginning and constructed and operated by four special public corporations including the Japan Highway Public Corporation. In 1970, Japan introduced a revenue pool system that unifies management of the balance for national networking maintenance. That nationwide public corporation was separated and privatized under the reform of special public corporations. The aim of the reform was to reduce its ballooning debt burden, which was generated after many unprofitable local lines of the regional support type were constructed and internally subsidized under the revenue pool system. Using separation of ownership and operation, the operation was separated into six local stock companies. The debt was assumed by the Japan Expressway Holding and Debt Repayment Agency, which has taken over the assets of expressways. The expressway companies are not allowed to make a profit from expressway projects. Almost all the collected toll charges are transferred to that agency, which uses the money to repay debt. Its primary revenue stream is related businesses such as sales at rest areas.

Now new roads are constructed following two methods based on profitability. For a toll road, the expressway company is the operating entity that constructs, renovates, and maintains the road by borrowing, and uses collected tolls for repayment and maintenance costs. For a fee-free pure public type road, national or local governments bear the costs under the newly government-owned expressway method. The government bears three-fourths of the construction and renovation cost and all the maintenance cost. Local lines, which were maintained under the regional support type, are now maintained under two types: a public–private mixture type or a large project type for profitable lines, and a pure public type for unprofitable ones.

Regional Division: JR and Third-Sector Railways

Most of the Japanese railways, which stretched nationwide as private projects at the end of the 19th century, nationalized before and after the Sino-Japanese War or the Russo-Japanese War for military reasons, and were transferred to Japanese National Railways after World War II. Subsequent motorization aggravated the railway business. Japanese National Railways isolated its enormous debt in 1987, and it was privatized and separated into seven railway stock companies: six for passengers and one for freight. The passenger companies are involved in both infrastructure and operation, while the freight company operates on tracks owned by the passenger companies.

Later, four JR companies on the main island and Kyūshū became perfectly listed companies. As Japanese National Railways were privatized and separated, many unprofitable lines were either abolished or handed over to other organizations such as third-sector companies.

Separation of Ownership and Operation: The EU Railway Policy and Its Applications in France and Germany

Most European Union (EU) countries suffered from worsening conditions surrounding the railway business due to motorization. Sweden was successful in rail operation after it separated the ownership and operation with an aim to put rail and road on equal footing in 1988. Based on this experience, the EU required its member countries to accept common rail policies: to separate the ownership and operation of rails and to ensure open access to their markets. Each member country obeys these rules but has its own unique features as shown below.

Despite the separation between ownership and operation, both the owner and operator of French arterial railroads are public corporations, and this frame strongly reflects the policy that railways should be a nationwide state-run business. The French Rail Network (Réseau Ferré de France, or RFF) owns the facilities and the National Society of French Railways (Société Nationale des Chemins de Fer Français, or SNCF) operates the railway.

The French railway network was first developed mainly by private companies, but their business conditions began to deteriorate in the 1930s. The socialist regime before World War II established SNCF, with which they integrated the main private rail companies. The business remained depressed even in the 1960s. When they separated ownership and operation in the 1990s, they transferred the ownership and management of the facilities as well as the long-term debt of SNCF to RFF. SNCF pays a facility charge to RFF, with which RFF repays the debt. RFF also manages the interest using some methods including refunding. SNCF focuses on the railway business operation. There is a clear distinction of their roles. Local railways other than arterial railways are operated and financed by local and national governments.

German railway companies are divided regionally and functionally (separated ownership and operation) and are controlled by the government due to the shareholding relationship. As the government holds all the stocks of the holding company German Railway (Deutsch Bahn AG, or DB), all the major railway companies are essentially governmental DB subsidiaries, including the companies of train operation, freight operation, infrastructure ownership, and local railways. They operate the railways according to the EU directive of open access policy; trains of other rail companies such as foreign ones can be put on the rails in Germany.

Germany is a federal state with many private rail companies and state rail companies. After World War I, all the companies were integrated into a national railway, which supported Nazi military action. After World War II, both East and West Germany established national railways, which were integrated into DB after the reunification. As is the case with other countries, a harsh operating climate due to motorization led them to privatize.

One of the characteristics of the separation of German railways is that the federal government holds all the management rights using the authority of the holding company, while they establish many subsidiaries based on functions to realize a decentralized railway business operation. On the other hand, state governments manage local or urban railways, and they commission operation to companies selected in competitive bidding.

Separation of Ownership and Operation, Regional Division, Private Consignment, and Subsidy Policy: Franchise System of UK Arterial Railways

UK arterial railways separate ownership and operation; the public sector owns the rail track and calls for bids for operation under a franchise system. An even more significant feature is that many functionally divided companies of train operation, train leasing, and traffic light maintenance pursue efficiency under a competitive system of open access in each functional area.

The franchising system is one where the rail network is divided and railway operators are selected in each area based on bidding. As many train lines are always in a deficit, the company that offers the smallest governmental funding can usually get the operation rights for 7 years when bidding for those lines.

British Railways, which started after World War II, had mainly operated arterial railways in the UK. However, business difficulties caused the government to decide to divide it into regional entities and privatize it in accordance with EU directives. This is when they separated the railway infrastructure from train procurement and operation and introduced franchise bidding for passenger rail companies. They were subdivided into about 100 different companies based on function and region, including 25 for regional passenger transport, 6 for freight transport, 14 for traffic light management, and 3 for train leasing.

The UK's open access policy invited foreign capital. Japan won a large market share in train leasing, while countries like the United States (US) operate railways in some areas under the franchising system.

As can be seen, British railways are much more market-based than those in France and Germany. The competitive environment in various areas makes the operators increase their business efficiency.

However, ownership of infrastructure is an exception. A private company called Railtrack first owned the railway infrastructure. That company got listed, but their poor maintenance caused by their pursuit of high dividends caused frequent accidents, and a large amount of compensation to the victims of the accidents drove them into bankruptcy. After that, Network Rail,[7] a nonprofit organization, acquired Railtrack and took over the railway facilities.

---

[7] Unlike Japan's nonprofit organizations, this organization reinvests all the profits instead of producing dividends as it does not have shareholders.

Separation of Ownership and Operation, Privately Built and Publicly Operated: US Passenger Railway Amtrak

Unlike in the UK, some private companies own infrastructure and the public sector utilizes it. US freight railway companies lease their own facilities including rail tracks to the public railway company Amtrak so that they can continue the unprofitable passenger service.

All of the American railways have long been maintained and operated by the private sector. Governmental involvement is extremely limited in terms of time and place. Although the US government established the United States Railroad Administration for military purposes during World War I and successfully promoted it to reduce overlapping train schedules and to standardize vehicles, the administration dissolved after the war in 1920 because its purpose had been completed.

Postwar motorization and advancement of the aviation network worsened the business conditions, and many companies went bankrupt. To solve this problem, two federally funded companies were established: Consolidated Rail Corporation (Conrail) in 1974 and National Railroad Passenger Corporation (Amtrak) in 1971.

Conrail, dealing mainly with freight transport, took over six bankrupt private rail companies in the American Northeast and improved management through discontinuing unprofitable lines. It was later privatized and bought out by a competitor.

Rail freight remains competitive in the continental US as an east–west long-distance transportation mode and maintains stable business performance. Passenger transport Amtrak struggles, losing more than $1 billion every year.

Combination of Ownership and Operation, and Publicly Built and Publicly Operated: The Autobahn in Germany

The Autobahn is maintained and operated with German federal funds. The government has revenue for long-distance road construction from mineral oil taxes. While the Autobahn is a freeway in general, it recently started charging only for heavy trucks for the sake of harmony with other countries in the EU's integrated market. This means that it could be called a pure public good only in the case of cars and vans according to our classification.

Germany first constructed a toll road, HaFraBa, connecting Hamburg, Frankfurt, and Basel. With the Great Depression in the late 1920s, the Nazis started constructing the Autobahn using public assets.

Maintenance of the Autobahn was interrupted by World War II and was restarted by West Germany after the war. As they used mineral oil taxes for the construction, the road was free of charge to use. The Autobahn network was rapidly extended after the 1960s. The unmaintained Autobahn in East Germany was swiftly reformed after the unification of East and West Germany.

Germany also promotes PFI or PPP to deal with the severe national fiscal situation and increasing road improvement expenses and maintenance costs, but only in some projects such as bridges and tunnels.

Separation of Ownership and Operation, Publicly Built and Privately Operated: French Highways

French highways have been toll roads as in Japan. They are now owned and managed by the public sector Autoroute de France and operated by a concession company. As France was delayed in highway maintenance compared to Germany, it was the Sociétés d'Économie Mixte Concessionnaires d'Autoroutes (SEMCA), consisting of five semipublic companies, that took the lead in maintenance according to the Highway Act in 1955, which established the frameworks for toll roads. The government is basically in the position of arranging concession agreements with these companies, but in reality, it is involved in many ways from planning to management.

At that time, demand for highway construction was high, and it was necessary to expand the organizations that construct and operate the facilities. Eligibility criteria for screening companies entrusted for concession were abolished in 1970. Because the government involvement was reduced, concession companies started to carry out a detailed study of rail tracks and land acquisition, which was work that had been done by the government. This policy change attracted some private companies to the railway concession market.

As the management gap widened among concession companies, some of the concession companies were acquired by SEMCA. The French government virtually started to separate ownership and operation of highways after the public sector Autoroute de France was established to manage the assets of SEMCA. After unprofitable SEMCAs were integrated into profitable SEMCAs, the surviving ones fully opened their stocks in 2005, which meant that all the concession companies were formally changed from semi-governmental to private companies.

Regional Division and PFI Introduction: British Highways

The M1 motorway opened in 1959 as the first highway in Britain. At that time, highway networks had already been developed in the US and Germany. Highways England, which is an agency of the Department for Transport, has been in charge of the construction and management of 7,000 kilometers (km) of highways and arterial roads.

Although UK motorways are basically free and are funded mostly by the government, they sometimes apply DBFO for investment operations including new construction and renovation projects because of today's difficult state of public finance. This is called a shadow toll, where a private company maintains and operates motorways, and the government instead of road users pays most of the expense derived from traffic use. They divide the country into 12 areas and delegate maintenance work in each area to a private sector entity every 5 years.

The UK is well known as the birthplace of PPP or PFI. The context of this was a severe shortage of road resources. There are eight sections (600 km) of roads including two sections of motorways on which Highways England, a motorway management organization, signed an outsourcing contract with private companies for large-scale renovation, long-term maintenance, and funding. The DBFO methodology was applied to these roads. There is no charge for use of these roads because they are operated under the shadow toll system (except for some bridges, tunnels, and one section called the M6 Toll).

Combination of Ownership and Operation, Management by Local Governments, and State Aid: US Highways and Japanese Public Corporations for Local Roads

The state governments in the US have been responsible for planning, construction, and management of US highways since their construction started in the early 20th century. Interstate highways can get federal subsidies. Both state highways and interstate highways are basically free. The interstate highways started being built just after World War II. That was because the highway connections between states had been revealed during wartime to be so poor that military logistics needed nationwide road connection improvements. Nationally uniform standards of road maintenance started when they enacted the Federal-Aid Highway Act of 1956. The Act states that the government subsidizes construction of interstate highways that meet certain standards, using a special account funded, for example, by motor fuel taxes.

There are 60,000 km of interstates maintained under the federal law. Despite the term "interstate highway," they are constructed and managed not by the federal government, but by the state governments. The American Association of State Highway and Transportation Officials issues guidelines for the road standards. The federal government selects plans that meet the standards, and the Federal Highway Administration, which is an agency of the Department of Transportation, subsidizes them. Toll roads, which are ineligible for subsidies, account for less than 10% in most of the states.

Since aging highways built in the 1950s became a big issue in the 1980s, unprecedented growth has occurred in the construction of toll roads and privately funded road maintenance (such as concessions) to handle the shortage of road revenue.

Japan's regional road public corporations established by local governments own and operate the facilities. Based on the Local Road Public Corporation Act, they build and manage toll roads and parking. The local governors must approve the budget and financial results. The local governments can guarantee the debt of the local public road corporation while the central government can only compensate for disaster recovery.

Public Subsidy: Japanese Local Private Railways

Almost all the local small private railways in Japan today receive government aid. A common case is that a railway company uses operation revenue for daily operating expenses, and public sector entities such as local government cover the maintenance cost of facilities including train cars. We can observe other public assistance along with official aid. For example, an external entity of local government could support local railway companies by donation, bulk purchase of coupon tickets, and so on.

The local railways that were detached from JR when Japanese National Railways (JNR) was privatized could perhaps be said to have received the most extensive public aid. These "branch-line" type railways had shifted their management from the parts of a national semi-governmental company (JNR) to local third-sector companies, and received grants depending on the line's distance. The company that received that grant became able to withdraw the funds when it needed to compensate for the deficit. However, this policy did not work as business support; the railway business revenue as well as the gain on management of funds greatly decreased after the bubble economy's implosion and the extension of the zero-interest-rate policy beginning in 1999.

3.3.4.5 Future Trends

Regional support type infrastructure projects in the world are in the process of trial and error. Although there are a variety of types within individual cases of regional support type infrastructure projects, the big trend is to reduce the involvement of government and its agencies in the operation of infrastructure and to explore other ways for private enterprises to operate infrastructure.

The separation of ownership and operation, as well as the public burden of fixed cost in the areas where demand for infrastructure is low, are already entrenched in many countries. The next question is how to reduce operating expenses while maintaining service standards. One answer is the franchise system in UK railways to introduce the principle of competition. Infrastructure service supply in regions tends to be monopolized by one company. In such cases, the government sometimes tries to create competitive market conditions even if this is virtual, for example by adopting periodical repetition of bidding. Plus, automation and ICT will be increasingly promoted to enhance operational efficiency in the future.

These business skills are important, but not as important as demand generation itself. There must be plenty more room for creativity in generating demand for infrastructure. At the same time, the expansion of infrastructure use should bring about a revitalization of the region.

3.3.5 Early Stage Subsidy Type

3.3.5.1 Characteristics

Because infrastructure service requires many facilities from the beginning of operation, recovery of the initial investment accounts for a substantial portion of operating costs. This type of industry, including infrastructure services, has a common feature of "decreasing average cost."

Average cost can be calculated by dividing the total cost of service by the amount of usage. The total cost consists mainly of the recovery costs of the initial investment such as repayment of debt. It also includes operating costs such as labor and fuel costs.

It will be easily understood that the total cost of water supply to a region cannot be strongly influenced by an increase in usage if it is within the capability of the facilities. That is, in the case of water supply services, the average supply cost decreases as demand expands. In contrast, a labor-intensive service business needs to increase the operating cost to provide more service because operating cost—especially labor cost—makes up a high proportion of the total cost.

As the initial cost of an infrastructure project tends to be huge, the repayment burden poses an obstacle to commercialization. That is where the idea of early subsidy came about. According to this methodology, the public sector pays the operating cost or the initial cost until a project gets on track to promote commercialization.

Infrastructure projects usually take a long time. Even if there is not great demand in the early stages, external effects of the construction can bring more people and thriving industry to the area, which might eventually lead to high demand for the infrastructure itself. In this case, the profitability of the project is obviously going to improve.

3.3.5.2 Operating Entity

When it comes to initial aid type projects, operating entities play different roles in the early stage and maturity stage. In the early stage, public involvement is usually necessary because the operating entity has to raise construction funds and it also has to bear the operating cost while demand is low. On the other hand, private operation is promising when the project develops, initial investment is recouped, demand expands, and profitability is expected to stabilize or increase.

3.3.5.3 Example of Initial Aid Type Projects Such as Public Water Supply Business and Public Transport Business

The initial aid type can be seen in many infrastructure projects. We will look at the examples of the public water supply business and the public transport business, looking at the way of privatization and its implementation.

Regarding the public water supply business, most of the water suppliers in Japan are local public companies, and they number more than 2,000, including 800 “simple water suppliers” (the term for small-scale private water suppliers in Japan).

Japan has almost completed investment in water supply-related facilities with a 98% penetration rate, so it has come to focus mainly on maintenance. The price of the water supply is set based on the general cost principle on the premise that one company supplies an area exclusively, so the payback risk is low. In fact, many entities successfully redeem enterprise bonds issued at the time of construction. Today’s water suppliers have a capital ratio of more than 70% on average, which is as good as the blue-chip pure private companies in terms of finance. Of local public water suppliers, 90% maintain a budget surplus.

As most of Japan’s water supply business has completed repayment of initial investment, some people believe that from now on these suppliers should be privatized or have a concession scheme applied in regions where there are business possibilities so that they can improve business efficiency.

By contrast, Japan’s sewage coverage rate is only 77%. Its maintenance is based on the idea of initial aid. The construction cost (initial cost) is basically covered by governmental subsidy, tax revenue of local governments, and long-term debt such as public enterprise bonds, while current expenses including maintenance costs and depreciation costs are covered by sewer charges and tax revenue of local governments. Stormwater treatment cost comes from general accounting, and sewage treatment cost comes from sewage charges.

As for the public transport business, let us discuss Osaka Metro. The first subway in Osaka was the Midōsuji Line, built in 1933. The construction needed so much initial investment that the city office had to collect taxes from the beneficiaries based on the benefit principle of taxation (Section 2.1) in order to finance the project. Though they were in the red for a long time because of the burden of redemption of the construction cost, the number of users increased gradually, and after the redemption finished, the line became highly profitable. Later, they created new lines using the internal subsidization method, which means to cover the deficits of other lines with the profits of the Midōsuji Line.

After the new construction of underground railways was almost finished in Osaka in 2000, the business performance of Osaka Metro lines improved. In 2003, they got into the black ahead of the public subways of nine other cities across Japan. They kept running a surplus of about ¥20 billion each year and solved their cumulative deficit in 2010. Osaka City formulated a draft metro business privatization plan in 2016 and privatized it as Osaka Metro in 2018.

3.3.5.4 Future Trends

There is a big trend of infrastructure projects in the world being privatized where it is effective to reduce the public burden and increase business efficiency. From this point of view, we should continuously consider whether the public sector needs to be involved in every stage from construction to operation in the case of initial aid type projects, particularly if the project is expected to be stably profitable. On the other hand, many third-sector companies still bear desperately unprofitable projects as we have seen with regional support type projects. We need to think carefully about this contradiction.

3.4 Private Business Type

3.4.1 Overview

3.4.1.2 Characteristics of the Private Business Type

From the viewpoint of reducing public burden and improving management efficiency, those infrastructure projects that can be expected to be profitable and procure private capital should be conducted as private businesses.

However, the market for infrastructure services has unique characteristics. If an infrastructure service is provided by private companies, the government may carry out necessary market regulation. The following viewpoints are particularly important: (i) possibility of a regional monopoly, (ii) fairness of competition conditions, and (iii) maintaining and expanding regional competitiveness.

Pros and Cons of Regional Monopolies

For infrastructure businesses, it has been pointed out that the proper competitive environment in the region tends to be impaired, which causes harmful effects of so-called natural monopolies (regional monopolies). The reason for a natural monopoly will be explained in the next section. When a certain company gets a dominant position, it will pursue excess profit by setting high fees. In addition, governments and local governments may grant exclusive supply rights to specific business entities in advance to avoid double investment. When doing this, various public regulations are required to avoid harmful effects of regional monopolies.

Fairness of Competition Conditions

In connection with infrastructure development, we often see that the same types of services are provided by different business entities within the same area (e.g., electricity and gas, railroad, and aircraft). Securing redundancy (margin) while maintaining the regional welfare level requires an evenly competitive environment among industries (equal footing, etc.).

Maintaining and Enhancing Regional Competitiveness

Some infrastructure deeply and directly relates to the competitiveness of the country or region and has a great influence on the development of the country and region (e.g., hub airport, hub port). Regarding this type of infrastructure, it must be strengthened as a measure to strengthen the competitiveness of the country or to activate the region.

3.4.1.3 Main Business Methods

Unlike government agencies and public corporations, private enterprises generally have few stakeholders, and the speed of decision making is fast. They have a high degree of freedom in their activities and a clear organizational purpose. In other words, by pursuing profit they can capture various business opportunities and create new business opportunities by showing ingenuity, and they can act flexibly to make these things happen. Many business methodologies have been created related to infrastructure, which public organizations are unable to apply. The representative examples are (i) internalization of external effects, (ii) combining and diversifying projects, and (iii) horizontal development.

Internalization of External Effects

Because of its nature, infrastructure is often subject to public regulation that prevents it from setting a fee that would make the business highly profitable. As a result, the user can enjoy benefits exceeding the usage fee.

The benefits exceeding the usage fee apply not only to the user. For example, they appear outside the infrastructure business, like an increase in land prices in front of the train station. This is called an external effect.

Public business entities cannot capture benefits that occur outside the project scope because the scope of the project is strictly determined by the establishment laws and ordinances. On the other hand, in the infrastructure business managed by private enterprises, by diversifying the business to, for example, the real estate industry and the distribution industry, it is possible to increase the sales of their total businesses by improving traffic conditions. In fact, private infrastructure companies think that such activities are vitally important because they lead to the expansion of comprehensive earnings. Abundant examples are found in private railway projects.

On the other hand, there are also negative external effects such as exhaust gas along the road, noise around the airport, and vibration near the railroad. For such negative external effects, business entities may be required to provide compensation.

Combining or Diversifying Projects

Many attempts have been made to diversify the business and expand profits with the infrastructure business as the core.

For example, many private railway operators in Tokyo and other metropolitan areas have developed houses for sale in the areas where their own railroads could become a means for commuting, generating revenue in the real estate business (internalization of external effects). In addition, they encourage population concentration along the railroad line to form a market of a certain scale, and a corporate group provides various services for this market. Their strategy is to make synergies between these businesses and ensure comprehensive profitability. Examples of business diversification of infrastructure operators include the bus business, distribution business (department stores, shopping centers, supermarkets, convenience stores), information business (cable television, etc.), education business (schools), elderly services (nursing care business, elderly housing), entertainment business (baseball stadiums, theaters, cinemas), and energy business (electricity and gas supply). These efforts by Japan’s major private railway companies are now a leading model of business development of the third-sector railroads and JR companies. In addition, there is the Ekinaka (inside-the-station) business, a unique model that realizes exclusive sales using the fact that the area inside the ticket gate of the station is a closed space, making the customers a captive audience. The service area and parking area businesses of highway companies also fall under this category.

In addition, corporations that are engaged in a business of one type of infrastructure sometimes enter another type. Some port operators in the US (port authorities) have diversified into the management of access traffic (roads, railroads) to ports, the development of real estate in port areas, and the operation of neighboring airports (e.g., US Port Authority of New York and New Jersey).

Horizontal Expansion

Private companies pursue business opportunities. They actively seek to apply the know-how gained in one infrastructure business to other infrastructure projects.

For example, Hutchison Port Holdings (HPH), originally a port operator in Hong Kong, China, is now one of the world's leading mega-terminal operators operating 319 terminals at 52 ports in 26 countries across Asia, the Middle East, Europe, North America, and Africa.

The expansion of port operators from one port to others has an aspect of risk avoidance. For example, Hong Kong Port, the home of HPH, ranked first in the world for containers handled during the period 1989–2004, but after that it was sluggish, and in later years various ports in the southern part of the People's Republic of China were rapidly growing. HPH entered into major ports including Guangzhou Port in the Pearl River Delta in the south of the People's Republic of China as an operator. In addition to forming a port network in the southern region, it has already handled in this area cargo whose volume exceeds Hong Kong Port.

Tokyu Railway Company in Japan, taking advantage of the management of the railway business and the development experience of the Tama Country City, is also working on new urban development in Viet Nam and business development for concessions at Sendai Airport. Viet Nam's Binh Du New City Development plans to develop a new city 30 km north of Ho Chi Minh City, a total area of 1,000 hectares, a planned population of 125,000 people, and employment of 400,000 (both by 2020). The Tokyu Corporation will establish a company to develop as a joint venture with a local company and provide know-how to the housing development and bus businesses.

At Sendai Airport, whose control tower and runway were originally controlled by the central government, a third-sector company was responsible for the operation of the terminal building. Recently as the first airport privatization project in Japan, contractors were invited publicly, and a consortium of the Tokyu Group and other companies won the operation rights. The Tokyu Corporation has developed a variety of derived projects in the process of their regional development. It is said that real estate managers in the group have undertaken outsourcing of the management work of other airports, and this achievement has become the key to new airport business development. Their experience of comprehensive efforts for transportation projects and regional development is expected to help with the local revitalization of the Sendai Airport area.

3.4.2 Supply Control Type

When infrastructure projects are entrusted to market principles of free competition, a natural monopoly will happen. This is pointed out as a risk of market failure. Various regulations are carried out to eliminate harmful effects of natural monopolies. Let us call this type of infrastructure the supply control type.

It is said that where the initial investment is huge and multiple enterprises are placed in a free competitive environment in a market where stable long-term demand is expected, one player tends to completely exclude the other and try to form an exclusive position. The resulting monopoly state is called a natural monopoly.

For example, in the early stages of construction of the transcontinental railway in the US, there was intense competition for acquiring customers and acquisitions among multiple railway companies that operated parallel routes. Those who won the competition could recover the funds spent on competition over a long time as long as railway demand continued. Conversely, the losers were no longer able to collect on their huge initial investment. Since the difference between victory and defeat was so clear, the competition among infrastructure operators was extremely intense, and it easily invited cut-throat competition such as setting dramatically low prices. Business operators using these tactics were prepared for a temporary deficit.

The business owners who survived such competition and occupied the monopolistic position would increase pricing to earn excess profit and would limit the users, hindering the maximization of social welfare. The economic loss in society caused by the inhibition of the function of the competitive market system is called deadweight loss.

Furthermore, if businesses withdraw from competition, their huge initial investments become uncollectable and the value of the assets left in the area declines markedly. Those railroads, towers, tunnels, and bridges that are unlikely to be used become huge bad assets. This is obviously a social loss, which is called sunk cost.

A natural monopoly brings socially significant losses in these ways. For this reason, in the field of infrastructure projects where there is a possibility of a natural monopoly, public regulations are set for entry and exit into business and usage fees.

3.4.2.1 Business Entity

In the supply control type market, as mentioned, entry is regulated. Those business entities who plan to enter this market are required to have a certain official character; for example, they must prove that they will fulfill their responsibility for providing stable services. For this reason, even a purely private enterprise is influenced from administrative orders. Japanese electric utilities were allowed to have regional monopolies but were at the same time obliged to provide stable services. Many of them are not general corporations but are local governments or their agencies.

3.4.2.2 System: Entry, Exit, and Rate Control

Regulation of Entry and Exit

To advance into the infrastructure business, in many cases, public regulation is established even for pure private enterprises regarding entry into and withdrawal from business. For example, those who intend to offer transportation services for passengers or cargo by laying a new railroad must receive a prescribed examination and obtain approval from the Minister of Land, Infrastructure, Transport, and Tourism. When the companies that operate in fields such as electricity, gas, and telecommunications withdraw from their business they must get permission from the Minister of Economy, Trade, and Industry before they stop providing services. Such regulations are required because there is an obligation on the part of the service provider to supply to the people, and the government has to eliminate the adverse effects of natural monopolies, as mentioned above.

Since infrastructure projects form a fundamental part of the social economy, high stability is required for service provision. In the practice of regulating entry, it is important to consider whether the business entity has the capital strength, scale, personnel structure, and technical capability to bear such responsibilities. Regarding exit as well, official examination is required because of the social importance of infrastructure projects.

The existence of these regulations is not compatible with the fundamental idea of the liberal economy that market entry and exit should be basically free. In other words, the existence of such regulations impedes the price adjustment function by market mechanisms. A business entity that has the right to exclusively supply essential services to a designated area will not be conscious of competition because it is shielded by entry regulation. Therefore, it may set a high price or may neglect management efficiency. For this reason, entry and exit regulation and the following fee restrictions are not mutually independent but need to be thought of as complementary policy means.

Price Regulation

In infrastructure projects that are subject to restrictions on market entry and exit, when establishing toll collection, pricing cannot be entrusted to market mechanisms, and the fee must be intentionally decided. The rate must have a basis that is just enough to obtain social consent.

Theoretically, it is said to be socially desirable to set the price of an infrastructure service equal to the marginal cost for a fully competitive market (a "perfect market"). This is called the marginal cost price formation principle. Marginal cost is the additional supply cost required when usage increases by one unit. The reason why this methodology is socially desirable is that by applying the method of the marginal cost pricing principle, we are said to be able to realize a Pareto optimal state.

Pareto optimality is a state in which the utility of one person cannot be increased without reducing the utility of someone else in the context of economic activities in which there are a plurality of members. In fact, because infrastructure has nonrivalness, if an additional facility user pays additional costs, there will be no negative impact on the business entity or other users of the facility. In that sense, it is interpreted that a Pareto optimal state will be realized if price equals marginal cost.

However, like infrastructure, when the initial investment is massive and the use of service is non-competitive, the marginal cost is significantly reduced. Therefore, applying the marginal cost price formation principle could cause the business entity to suffer a loss. For example, suppose that the expressway operator plans to set the usage fee based on the marginal cost price formation principle. If the number of users is 20,000, an increase of one or two users may require almost no additional cost for the service operator. This means that the marginal cost is nearly zero. If the expressway operator sets the usage fee close to zero for that reason, recovery of initial investment becomes impossible, and it will not be established as a business for private enterprises.

Like this case, businesses with massive facilities and extremely low marginal costs are sometimes called capital-intensive industries. These capital-intensive industries, or decreasing cost industries, are characterized by making huge investments, forming massive fixed assets, and providing services by operating these fixed assets. The operating cost of the facilities is almost stable and not dependent on the number of users. Therefore, if the usage increases, the average cost (cost per unit of usage) decreases. Because an increase in usage leads to a decrease in the average cost, it is called a decreasing cost industry.

It must be clear from the example of the expressway that in the case of a capital-intensive industry, marginal cost hardly exists, while a huge investment must be recovered. For this reason, it is highly probable that the business will suffer losses if the usage fee is determined by the marginal cost pricing principle.

In the perfect competitive market, the marginal cost price formation principle is said to be theoretically ideal, but applying it to the infrastructure business is difficult. For this reason, appropriate regulated prices are decided through discussions based on sub-optimal arguments (not on the cost price formation principle). In that case, the most important requirements are (i) to choose a pricing system that allows the operation of the project entity and (ii) to maximize social welfare under that condition. We call rate setting that satisfies these requirements Ramsey pricing. To attain this, various ideas have been devised. The details on this are in Chapter 6.

3.4.2.3 Regulation of Water Supply and Sewerage and Electric Power Business

Water Supply and Sewage System

Water supply is indispensable for human survival, especially in urban areas. For that reason, it is considered reasonable for public agencies to bear responsibility for supply. In fact, local governments are also the main business entities in various countries around the world.

In Japan, since the first waterworks project in Yokohama City started in 1887, nationwide maintenance has continued, and at present, the penetration rate is 98%. In the remaining 2%, there is no need for water supply improvement as groundwater is abundant, so the actual penetration rate is said to be 100%.

In Article 6 of the Waterworks Act, "those who intend to operate a water business must receive approval from the Minister of Health, Labor, and Welfare," and "municipalities operate the water supply business as general rule; those other than municipalities shall manage the water supply business only after obtaining the consent of the municipalities." For this reason, even prefectures cannot run water supply businesses unless the consent of municipalities is obtained. This is entry regulation. Meanwhile, the water fee is required to be approved by the Minister of Health, Labor, and Welfare.

Now that Japan's water infrastructure has been improved to a certain level, maintenance and management are the main objectives, and the need to improve management efficiency has emerged as a serious problem. Particularly, in some parts of the country where the population has declined and so have industries, it is becoming difficult for municipalities to secure the income and expenditure of water supply projects. For this reason, even in the water supply business, discussions have begun on privatization and on expansion of supply target areas by merger.

Regarding the expansion of the supply area, there are some examples: certain multiple municipalities form a basin waterworks corporation team, and some prefectures are entrusted by municipalities as the water supply entity with the use of the designated manager system. In sewers, the entry of foreign companies is also seen. For example, France's Veolia Water Company (described in detail later), which operates water supply and sewerage in various countries, also conducts sewage treatment plant management services in Tega-numa and Inba-numa in Japan.

Electric Power: From Regional Monopoly and General Cost Method to Shipping Electric Separation (Liberalization)

Historically, the unit price for electricity in Japan was determined based on the fully distributed cost (FDC) method. Practically, the total target revenue was set to be the sum of all expenses multiplied by a certain ratio called the project compensation rate. The price per unit was derived by dividing this by the assumed usage amount. The FDC method clearly presupposes securing the profit of the business entity. It also makes it easier for the business entity to establish long-term plans such as capital investment and maintenance repair. Japan's electric power companies were allowed regional monopolies because they had the obligation to provide a stable supply. The FDC method was applied because the market principle did not work there.

The first law established for the electric power business in Japan was the Electricity Business Act, enacted in 1911. Here the fee was supposed to be the notification system. With the revision of 1931 it became an authorization system, and the FDC method was introduced by re-amendment in 1933. This is probably because importance was placed on the stability of the management of electric power companies because the spread of electric power use was remarkable.

During the Second World War, the supply of electricity was put under state control for price stability, and the national policy company controlled both the power generation and transmission. After the war, the electric power business was divided into regions and the fee returned to the authorization system, but the FDC method was maintained.

In recent years, however, the liberalization of electric power has been progressing, mainly in developed countries. What is in the background is the spread of recognition that a more appropriate (inexpensive) power supply is made possible by reducing national involvement and introducing the market function.

Specifically, the trend of the EU since the 1980s has had an impact on other countries. The basic idea of the EU energy policy is that the infrastructure of the electric power supply has already reached a certain level of maintenance and next it is important to improve management efficiency by introducing market principles. In 1997, an EU directive called for the separation of the power supply structure into a competition division (power generation and retail supply) and a regulation division (transmission and distribution network division), and the separation, privatization, and reorganization of power generation, transmission, and distribution progressed in each member country. As a result, huge public utility companies that comprehensively handle electricity, gas, etc. were born one after another. Examples include E.ON SE and RWE AG in Germany, the EDF company in France (Électricité de France SA), and Vattenfall AB in Sweden.

In Japan, the power supply regime is being reviewed using almost the same way of thinking as the EU. So many newcomers have entered the liberalized market of power generation and distribution since April 2016. The power companies were enabled to set electricity fees on their own by retail liberalization in April 2016. Power generation, transmission, and distribution are planned to be separated legally by 2020. The department of power generation and retail is where the competition principle was introduced. Transmission and distribution is a network infrastructure, and the permission system will remain in the future, but its use will be opened to power producers and power distribution companies including newcomers.

3.4.2.4 Future Trends

In the case of the water supply, in recent years, as infrastructure development has reached a certain level in developed countries, operation and management have become the core of the water supply business. Awareness has increased that improvement of management efficiency is essential for reducing the public burden. With this background, cases of privatizing business entities and entrusting operations to private enterprises are increasing.

The recent pioneer was the UK, which privatized water utilities in England and Wales in 1989. Also, in France, from the 19th century there was a unique privatization in a concession water service project.

Thanks to the universality of management know-how of water supply, administrators can extend their technical capabilities laterally to business in other regions and countries. Indeed, Thames Water Utilities Ltd, a privatized British water supply management company, is developing business as a water management company in Asia, South

Africa, South America, and elsewhere. Veolia Water, which has a long concession history in France, has already conducted water supply management projects in more than 60 countries.

The international business development of such infrastructure management companies is extremely large in scale, and the competition among companies is complicated and dynamic. For example, the above-mentioned Thames Water Company was acquired by German integrated infrastructure company RWE and was temporarily affiliated (afterwards being sold to an Australian company). Already the second largest electric power company in Germany, RWE has expanded the scope of its business to gas and water through aggressive acquisitions and is developing business in the US, Central European countries, the UK, and others.

Veolia Water belongs to a corporate group supervised by Veolia Environnement S.A., a company engaged in water, energy, waste disposal, transportation service, etc. The group is headquartered in France and delivers services worldwide. Most of their revenue comes from overseas.

In this way, in supply control type infrastructure such as energy and water supply, the movement toward market opening to the private sector centering on developed countries is progressing rapidly. Those companies who satisfy the entry and exit regulation and fee regulation that government authorities set can enjoy monopolistic business for a certain period. It can be said that stable earnings are likely to be expected from this market for those companies that accumulate know-how. With this background, many huge utility companies targeting energy and water as well as transportation have appeared as described above in Europe, where the infrastructure market was first opened to the private sector. Even in Japan, the era of liberalization of the supply system of electric power is coming, and soon it is also assumed that utility companies will emerge that are also responsible for supply of gas and water supply.

We have discussed the harmful effects of natural monopolies with reference to examples of catastrophic competition that were seen in US transcontinental railroads and the like. In other words, the theory was formed based on observation of corporate behavior that provides a single service (railway) in a specific area (North America). The events that are occurring today are largely beyond the framework of such discussion. As for the advantages and disadvantages of large public utility companies that develop worldwide, from the viewpoint of achieving the objective of proper management of infrastructure projects—that is, the maximization of social welfare—it seems that much remains to be seen in future observation and research.

3.4.3 Competition Adjustment Type

If multiple infrastructure projects exist within the same area, some sort of public adjustment will be required. Conventionally, equal footing was often discussed from the recognition that fair competition conditions are necessary when services of different infrastructure compete.

Today, in the trend of privatization of the global infrastructure business, adjustments are coming to be made from various viewpoints including equal footing, such as the introduction of a competitive environment and improvement of convenience for users.

3.4.3.1 Examples

Railway Policy in the European Union

In Europe, the railway transport volume decreased due to the spread of motorization in the 1970s, and the railway business management deteriorated. As a result, the growing cumulative debt of rail business entities and the increase of government subsidies became a common issue for member countries. There was also much debate over how to deal with unfair competition conditions for truck transport and rail transport. In other words, the usage fee of railroads, by which the business entity needs to cover the fixed cost burden such as railway facilities, is clearly inferior to the cost of road transportation where infrastructure is provided to the public for free. Unless fair competitive conditions could be established, the railway would have a hard time surviving. It was also obvious that the shift from railway to truck transportation needed to be controlled within a certain range from the viewpoint of decreasing the environmental burden and the like.

The policy derived from this "equal footing" theory is the upper and lower separation of the railway business, and in 1988 Sweden first put the theory into action and saw the effect. Based on this achievement, the EU decided to apply vertical separation in all member countries. The EU had another policy objective other than solving the cost difference problem between rail and road transportation. That was, like the truck business, to create a situation where individual railway carriers could freely come and go within the European region. In other words, within the scope of the Swedish case, the equal footing of railway and truck fees was focused on because that problem was seen as purely domestic. But in the case of targeting the entire EU, policymakers had also to aim at equal footing in the scope of business between rail and road.

As a result, under the EU directive of 1991, the railway operators of member countries separated the accounting of the transport sector and the railroad business department, and the latter started to allow other countries' rail companies to use their facilities, including railway tracks. Subsequently, the EU established common rules on railway business licenses, allocation of railway capacity, and railway usage fees. A new railway business environment was promoted that enabled country A's railway train to enter directly to country B, country C, and so on.

However, because passenger railways are generally unprofitable, many member countries participated in competitive bidding to acquire business rights and subsidies as a set and adopted a form in which the authorized rail companies provide services for a certain period based on the contract.

Railway Policy in the Tokyo Metropolitan Area

There are so many railway operators concentrated in the Tokyo Metropolitan Area, and mutual coordination is an obvious necessity. In fact, the central government plays a role in that adjustment. Specifically, the railway plan in the metropolitan area is carried out by the Transportation Policy Council (the old transportation policy council is one of the parent committees). The Council was established based on the Law for Establishment of MLIT and is responsible for deliberating and reporting important matters concerning transportation in response to inquiries from the Minister of Land, Infrastructure, and Transport.

One of the characteristics of the metropolitan railroads in Japan is that they have realized many interconnected through services. The connection of JR, private rails, third-sector rails, and subways are diversified, and users enjoy high levels of convenience. The benefits that result are called "economy of scope" in the sense that smooth long-distance movement widens the beneficiary area and increases the user's added value. Mutual direct entry of trains not only enhances the convenience of users, but also brings benefits in terms of operation for transportation operators. It eliminated the decline in driving efficiency associated with train turn back operation at the terminal station near the city center. Many vehicle bases moved to the suburbs where land prices were low, and the former vehicle base sites near the city center became available for use in urban applications such as skyscrapers.

Regarding fares, since the 1970s, fare restrictions have been implemented for major private railways by the "yardstick methodology." Since 1997, a systematic fare calculation method has been developed and applied to major private railways, JR, and subways.

3.4.3.2 Future Trends

The global trend of the infrastructure business is to introduce the principle of competition and enhance management efficiency after it has reached a certain level of development. At the same time, economies of scope are pursued as seen in the example above.

Looking at the current situation from this point of view, for example, the railway business in the big cities is very highly productive particularly after the initial investment is recouped. In these areas, privatization of public transportation enterprises will progress in the future.

3.4.4 Regional Strategy Type

Some infrastructure projects are closely related to the competitiveness of the country or region. Airports and ports are representative of this. For this reason, many countries have national policies to strengthen the functions of major airports and ports.

In recent years, privatization of the management entity has become a major axis for the policy of enhancing the competitiveness of airports and ports. This would prove that emphasis is placed on swift management decisions, improvement of management efficiency, and incorporation of user needs. In addition, as part of regional or national strategy, privatized business entities in infrastructure accumulate business know-how. Utilizing competitiveness derived from experience, some privatized business entities have obtained positions as operating entities of infrastructure in other regions and countries. In other words, those infrastructure business entities that experienced a lot of management freedom in one area later tend to try to plan and execute their own business strategies and extend them to other regions. In this sense, the name "regional strategy type" may only represent one starting point for infrastructure companies that operate internationally. There are many cases worldwide, among which we will see Singapore and France below.

3.4.4.1 Examples

Port Policy of Singapore

Singapore is a country with a small land area and population size and no natural resources. Former Prime Minister Lee Kuan Yew said that ports and airports are the most important facilities for the island country of Singapore. The government has been developing airports and ports as a national policy.

Initially the port operator in Singapore was the Port of Singapore Authority (PSA), a public corporation established in 1964. PSA was responsible for the development of port related infrastructure in general. In 1997, when the facilities had improved to a certain level, PSA was reorganized as a private company, PSA Corporation, wholly owned by the government with the aim of improving international competitiveness. Port supervision work and such were taken over by the Maritime and Port Authority of Singapore, a governmental organization, and the activities of PSA were specialized in the management and sales of logistics such as terminal operation.

Noteworthy about PSA is a thorough information technology investment on container handling. In 1989, PSA was connected online with traders, customs, the Singaporean government's International Enterprise Agency, and so on. Application of customs clearance, examination, permission, etc. could all be done on the networked computer system. This shortened the customs clearance procedure that took 1–4 days by document delivery to only 10 minutes. Operation management within the terminal was fully computer networked, automated, and centrally managed, and at that time they offered the world's highest level of efficient port service.

In privatizing PSA in 1997, the Singaporean government clearly intended its overseas deployment. Today, the company operates about 30 ports in 17 countries in Asia, the US, and Europe, using the know-how and technology cultivated in port management in Singapore.

Overseas Strategy of Paris Airport Company

The Paris Airport Company (Aéroports de Paris, or ADP) is the private company that succeeded in the function of the public facility corporation (similar to a special corporation in Japan) that had owned and operated the three major airports in the Paris area (Charles de Gaulle, Orly, and Le Bourget). ADP also inherited the operation of 10 ordinary aviation facilities and one heliport.

Historically in France, the central and local governments have owned airport facilities, and the local chambers of commerce and industry have been responsible for the management and operation. The major airports around Paris were managed by the government, and ADP was responsible for the practice from construction to operation management. In recent years, however, the importance of international hub airports has been considerably increasing with the expansion of air transportation. In response to intensifying competition between international airports, the French government privatized this airport management company in 2005. The purpose of the privatization was explained as follows: (i) it is possible to flexibly carry out the project by removing the business regulations imposed on public facility corporations and (ii) private capital could be incorporated by stock listing. At first, the government held all of the company's stock, but after that the company was listed and more than 30% of the shares were sold.

After privatization, ADP made aggressive investments of several hundred million euros, including expansion of Charles de Gaulle airport. ADP expanded the number of customers, which was around 50 million at the time of privatization, to 80 million in 5 years. ADP is also improving the position of airports around Paris as a logistics center, including attracting European hub facilities of the large international logistics company Federal Express. Furthermore, taking advantage of practical experience, ADP started managing nearly 20 airports in Central America, Africa, the Middle East, and Asia.

Privatization of Airports in Japan

Japan tried to improve the management efficiency of major international airports in response to the global trend. Representative examples include the privatization of the Narita Airport operating organization and the outsourcing of the management by concession contract of Kansai International Airport.

Narita Airport was long managed and operated by the New Tokyo International Airport Corporation, a special public corporation. However, the company received a report from the MLIT Transport Policy Council's Air Subcommittee that privatization was desirable from the viewpoint of clarifying management responsibility and improving management efficiency. First, it was made into a special company, a private company whose stock is all held by government, and it was decided to aim for listing (fully privatized). The current Narita International Airport Co., Ltd. is still unlisted; the shareholders are 90.01% the Minister of Land, Infrastructure, and Transport and 9.99% the Finance Minister. This is apparently a state-owned enterprise. The company is aiming for business development overseas based on the experience of management and operation at Narita Airport. In addition to conducting a number of consulting services overseas, the company also accepts foreign trainees.

Kansai International Airport was built using the landfill method offshore of Senshu, Osaka Bay, because of environmental problems caused by the progress of urbanization near Itami Airport (Osaka International Airport), and because of the excessive amount of arrivals and departures in the Kansai area. It is an international airport that operates around the clock. Most of the project cost was raised through borrowing, but the business entity Kansai International Airport Co., Ltd. (a special company, a majority of whose stock is owned by the government) suffered from the repayment burden. Meanwhile, since the Itami Airport continued operation even after the opening of Kansai International Airport, the company considered maximizing the business value by integrating the operations of both airports. As a result, the concession method was chosen.

The New Kansai International Airport Co., Ltd. was established as a management company of both airports in 2012. The company granted the operation rights to Kansai Airport Co., Ltd., which is a private enterprise special purpose company (SPC). The SPC was established through investment by entities including Orix and France's Vinci Airports SAS. Compensation for the operating rights paid by the SPC was used for early repayment of the debt from the construction of Kansai Airport.

With the company's operation of the airport, it is expected to increase the revenue significantly due to the increase in air demand and new development of passenger facilities.

3.4.4.2 Future Trends

Japan, like Singapore, is an island state, and its national strength largely depends on the level of its ports and airports. For this reason, the government is trying to narrow down the major airports and ports that have a major influence on the competitiveness of the country and trying to improve the management of the infrastructure by strengthening the business entities. The same efforts are taking place in Singapore and France.

As we saw in the examples of Singapore and France, the strategy adopted when the government tried to enhance the competitiveness of regional strategic infrastructure is to strengthen private management capabilities and to eliminate regulations in order to expand business opportunities. As already seen, the operation of major international airports is also privatized in Japan.

International competition over airports and ports is expected to intensify more and more in the future. Each country will continue to compete for management skills and capital expenditure on this critical infrastructure.

3.5 Financing Infrastructure Business

3.5.1 Funding

3.5.1.1 Business Entity and Fund Provider

As already seen in the previous section, the project entity is an organization that plans the project and plays a central role in the process of realization. It is essential for the project entity to raise the necessary funds to realize the project. The provider of funds may be a business entity (in cases where a private company conducts its business with its own funds). But infrastructure projects are a huge investment, so most cases involve external funding. In infrastructure projects, in many cases, there is a fund provider separate from the project entity.

In the case of a pure public type, the source of funding is public money such as tax revenue. By going through democratic procedures such as parliament approval of the budget, the government allocates the necessary funds to the project. In this case, the fund provider is taxpayers. (There is other fund-raising from investors and so on by issuing government bonds).

In public–private mixed type and private sector type infrastructure projects, external fund providers become clearer. They are financial institutions and investors. In the case of using self-financing, finally, it is necessary to persuade shareholders of the business entity.

For business entities, financing is always the biggest problem. It does not mean that it must clear certain criteria like the technical aspects of infrastructure. It is not a matter that can be arbitrarily self-determined, but the entity must form an agreement with the provider of funds. It is no exaggeration to say that all the various measures of investment evaluation detailed in Chapter 4 have been created for this consensus building.

3.5.1.2 Initial Cost and Running Cost

As we repeatedly mention in this book, the funding barrier is the initial cost. In the management stage, it can be assumed that operating costs (running costs, at least a part of them) are covered by toll revenue in infrastructure that can collect tolls. However, such income does not exist at the planning and construction stages. Business entities with infrastructure other than the pure public type will need to make fund providers interested by, for example, predicting future fee income or using it as collateral.

3.5.2 Form of Fund Procurement

Funding for infrastructure commercialization is roughly classified into the following five types:

(i) Government funds
(ii) Internal funds
(iii) Equity capital
(iv) Debt capital
(v) Other funds

Each item is outlined in Table 3.1. The repayment obligation and the degree of the interest rate greatly affect the business.

Table 3.1: Financing Methods for Infrastructure Business

	Meaning	Cases	Remarks
1. Public Funds	Administrative organizations procure them based on their authority (tax collection rights, etc.) and put them into business	• General expenditures • Special account • Subsidies	No repayment obligation
2. Internal Funds	Self-procurement within the organization by the project entity	• Internal aid • Internal reserves	No repayment obligation
3. Own Capital	Funding from investors expecting project profit distribution	• New stock • Bonds with stock acquisition rights • Fiscal Investment and Loan Program	No repayment obligation Profit distribution (dividend) objective
4. Borrowed Capital	Loans from financial institutions and/or investors who evaluate their business	• Borrowing in the market • Bonds • Fiscal (investment) • Development finance	Mandatory repayment With interest
5. Others	Players concerned (local governments, residents, etc.) promote commercialization by methods other than 1 to 4	• Local contribution money • Beneficiary contribution • Donation • Investment in kind • Decrease (reduction of private land area) etc.	...

Source: Authors.

3.5.2.1 Government Funds

Government funds are funds provided by a public organization (government or local public entity) to a project entity. Funding is based on general financial sources (such as regular taxes), specified financial sources (such as purpose taxes), issuing of public bonds, and so on. It is necessary to list it in the draft budget and receive approval from parliament.

Government bonds may be issued for the purpose of financing infrastructure projects. In the case of Japan, its creditworthiness can be said to be secured by municipalities and countries. In other words, future tax revenues are assumed as redemption funding sources. On the other hand, in some other countries, there are cases in which public bonds are issued as project finance with the source of redemption being the future profits of the project itself. This is called a revenue bond.

3.5.2.2 Internal Funds

In the operation of the infrastructure business, part of the revenue of a highly profitable business operated by the same company may be relocated to another infrastructure business. This is called internal assistance, as mentioned previously.

In addition, the project entity may use its own funds for the infrastructure project. Private companies will accumulate depreciation expenses and part of the profits gained from the project within the company as retained earnings. It may be possible to inject these internal funds into a new infrastructure project. Such internal funds are sometimes called retained earnings. Internal funds referred to here are conceptually included in "equity capital" in the next section.

Both internal aid and retained earnings rarely can cover the entire construction cost of new infrastructure, which is usually quite massive.

3.5.2.3 Equity Capital

Owned capital (equity) is also called net assets and means funds that business entities need not repay. It includes the retained earnings mentioned above as well as shareholders' equity, the investment made by the fund provider through acquisition of the shares of the business entity, which occupies a large position.

A fund provider that has acquired shares of the business entity is called a shareholder. The business entity is not obliged to repay the investment to shareholders. Meanwhile, shareholders acquire shareowner rights (voting rights at shareholders' meetings, the right to receive profits such as dividends and so on, the right to receive assets remaining in the dissolution of business entities) through equity investment. The investment can be said to be high risk and high return because it is subject to stock price fluctuation, that is, price fluctuation risk. One of other risks is that borrowed capital is given priority in the distribution of the remaining assets if the business entity goes bankrupt or is disbanded.

3.5.2.4 Debt Capital

Borrowed capital (debt) is the capital that must be repaid, which the project entity procured from the outside. The main items are borrowings and funds raised through issuance of corporate bonds. Both are also called interest-bearing liabilities because they generate interest. The fund provider who purchased the bonds is called the bond owner.

Unlike shareholders, bond owners cannot engage in management. The principal of the borrowed capital is preserved, and the investment is repaid with preference to the owned capital at the time of the bankruptcy or dissolution of the business entity. Compared with the acquisition of stocks, it can be said to be an investment of low risk and low return.

3.5.2.5 Loans: Corporate Finance and Project Finance

Borrowing from financial institutions is often done in financing infrastructure projects. Here, the concept of corporate finance and project finance is important.

Corporate finance is understood as a loan whose security is the whole activity of a business entity. Imagine that an electric power company that owns multiple power plants tries to borrow funds through the market to construct a new power plant. Financial institutions will evaluate creditworthiness such as assets owned by the company and profitability as collateral and determine the loan amount and the interest rate.

In the above example, project finance is not the creditworthiness of the electric power company, but a loan made on the assumption that funds for repayment will come from the cash flow expected to be generated by a newly constructed power plant. Collateral is limited to business facilities to be financed (in this case, the newly constructed power plant).

In Japan, most of the loans made in commercializing infrastructure are corporate finance. Meanwhile, in some other countries, project finance methods are actively used.

3.5.2.6 Other Funds

In addition to the above, various methods of raising funds have been devised and practiced in the commercialization of infrastructure.

Even in infrastructure projects that are expected to be unprofitable, donations and in-kind contributions (land, etc.) are common methods when the locality is enthusiastic about attracting the project. In addition, if a land readjustment program is applied, local landowners may contribute to substantial financing by responding to a reduction in the amount of private land following a land reallocation.

This is also an item to be classified as a public expenditure (as in the first category above). As a rare example, profit resulting from infrastructure development is absorbed by taxation etc. and there are cases where it is applied to the project cost. There are examples of how to identify beneficiary areas and increase property taxes and sales taxes.

In the US, increased tax revenue such as tax increment financing (TIF) secures funds procured by issuing bonds (TIF bonds). These funds are often applied to projects such as regional development implemented by local governments.

3.5.3 Actual Fund Procurement

3.5.3.1 Sendai Municipal Subway Tōzai Line: Portfolio Composition by Municipality

The Sendai municipal subway Tōzai Line is a route connecting 13 stations in 26 minutes. The total project cost estimated at the planning stage was ¥230 billion (¥16.5 billion per kilometer), and the number of users per day was 80,000 people.

The fare was first assumed to be in the range of ¥200 to ¥360, and even if all users paid the maximum ¥360, annual income would be only ¥10.5 billion. Based on these premises, Sendai City Transportation Bureau, the business entity, calculated the expendable amount (amount of corporate bonds issued with redemption fare income) of ¥74 billion. That was only about 30% of the total project cost.

The idea of Sendai City to make up for this difference was for the city to bear ¥104 billion and to acquire a national treasury subsidy of ¥52 billion.

Sendai City financed the above amount by issuing public bonds of ¥36 billion in addition to applying ¥68 billion from the local allocation tax grant. By constructing such a portfolio of funds, the subway fee came to be kept to a level that is easy to use as planned, while keeping the interest-bearing debt of the Sendai City Transportation Bureau within the payable range.

3.5.3.2 San Francisco Bay Area High Speed Railway: Reduction of Development Profits

In the area surrounding the San Francisco Bay, the Bay Area municipalities promoted the railroad construction plan called Bay Area Rapid Transit (BART) beginning in the 1940s. The construction was approved to begin by a referendum of the local residents in 1961. The railway started construction in 1964, and in 1976 the whole railway was opened (Figure 3.3).

The construction cost was $1,619 million (at the then fixed rate of $1 = ¥360, about ¥580 billion), and the financial resources were issuance of public bonds (general finance bonds), federal subsidies, and revenue

Figure 3.3: Bay Area Rapid Transit Network (San Francisco Bay Area)

Source: Illustrated based on Bay Area Rapid Transit information.

bonds. The reimbursement source of revenue bonds was set as an increase of sales tax within the beneficiary area of BART.

Very interestingly for people who do not live in the country, in the US there is an example of establishing a special purpose municipality and conferring the right of tax collection to that municipality. In the case of BART, the entity doing the planning, construction, fund-raising, and operation was the virtual municipality called the Bay Area Rapid Transit District established by the California State legislature.

This special district consisted of San Francisco and several surrounding counties. The special district collected the sales tax independently as an administrative agency. They issued revenue bonds with that tax income as collateral and put the obtained funds into BART construction.

In the US, there are often instances of procuring infrastructure project costs by returning development profits. For example, in the construction of the subway in Los Angeles, it collected about 10% of the total project cost by collecting benefit levies from the establishments around the station. Also, in the case of Denver's financing for the construction of the Light Rail Transit (LRT), the city issued public bonds whose collateral was the revenue of additional asset taxes on the beneficiary area.

3.5.3.3 Road Station Ibusuki: PFI and a Designated Manager System Combined

Kagoshima Prefecture's roadside rest area of Ibusuki is well known as the first example in the country that was developed using the PFI methodology.

This roadside rest area consists of a city park (12,000 m^2), a regional exchange facility (two steel frame stories, a total floor area of 809 m^2), a 24-hour parking lot (26 units), and a complex composed of a toilet and a road information guide device. It has a total area of 14,600 m^2 and a total project cost of ¥1.23 billion. The urban parks were developed with public funds (total project cost ¥480 million, including government subsidies of ¥200 million, bond issuance of ¥210 million, and general public finance resources of ¥70 million). The parking lots and the like were developed by the country (Ministry of Land, Infrastructure, Transport, and Tourism, Kagoshima National Highway Office, with a maintenance amount of ¥380 million).

The PFI methodology was applied to construction and operation of the community exchange facility. The community exchange facilities house tourist information centers, local products and dealers of agricultural products, food and drink facilities, etc. PFI applied was a BTO type. In other words, the private business operator built a community exchange facility using their own funds within the planning site and transferred ownership to Ibusuki City after completion. The city paid the private enterpriser for the building cost of the facility and the maintenance and operation cost of the road station for 15 years and avoided the burden of the initial cost. On the other hand, private operators paid the facility borrowing fee to the city and operate revenue projects through the operation of facilities. In addition, the private enterprise manages urban parks that are installed together by applying the designated manager system. The contract period is 16 years (1 year of construction, 15 years of operation).

Thanks to the PFI method applied by the city, the financial burden on the city government for 15 years decreased from ¥270 million to

¥180 million, a 37% reduction. This amount is the value for money always used when considering the PFI methodology.

In addition, as a measure to secure incentives for private enterprises, the city admitted that 20–40% of sales of souvenirs and the like sold within the community exchange facility would be made as private operator income as sales commission.

3.5.3.4 Millau Viaduct: Construction of Local Infrastructure by Private Funds

The Millau Viaduct (Viaduc de Millau) is a large-scale cable-stayed bridge with a length of 2,460 m that is part of the A75 highway connecting Paris and southern France. The height of the bridge tower is 343 m and it is known as the world's highest elevated bridge.

The construction and operation of the Millau Viaduct was done in concession form. In other words, it was made using the BOT method. The French government was to select business operators and granted project execution rights for a certain time. The selected operators were to be responsible for fund procurement, construction, and operation, and the ownership was transferred to the government after the project period. The one that gained the business rights from the government was Eiffage, a leading French construction company.

An SPC to become the business entity was established by the sole investment of Eiffage. The total project cost of the viaduct was about €400 million (about ¥40 billion), and this SPC borrowed the whole amount from the European Investment Bank. This loan was project finance, which is expected to be redeemed based on future business income.

The concession contract period between the French government and the SPC is 78 years, of which 3 years is for building and 75 years is for operation. The toll fee can be decided at the discretion of the SPC, and it is currently €8.2 during summer and €6.4 for all other seasons for passenger cars. Daily traffic volume is around 20,000, and it is also expected that redemption of the construction investment will be realized without waiting for the term of the concession contract. From 2045 onwards, the French government can request the business operator to terminate the concession contract by prior notice when the redemption of construction investment is anticipated so that the SPC cannot pursue excess profit.

This case is a huge and long-term investment, and businesses are also cautious about risk measures. For example, the funding plan is divided into two phases. The first phase is the first 5 years of design, construction, and operation. During this period Eiffage will unconditionally undertake the SPC's business risk (completion risk and unstable operation risk at the beginning of opening).

In the second phase, that is, after the sixth year of operation, Eiffage can freely sell up to 49.9% of shares of the SPC if it first notifies the government. In other words, this is an agreement between the government and Eiffage that if the SPC gets its business on track in the 5 years after the start of operation, Eiffage can enjoy the capital gains of the SPC's stock after that. As these contracts incorporate these merits, Eiffage decided to bear (guarantee) the business risk at the initial stage of the SPC.

It is clear from this case that various forms of financing can be designed by appropriately allocating risks and returns (income).

Bibliography

Section 3.3

Blackford, M. G. and K. A. Kerr. 1993. *Business Enterprise in American History*. Boston: Wadsworth.

Chandler, A. D., Jr. 1979. *The Visible Hand: The Managerial Revolution in American Business*. Cambridge: Harvard University Press.

Littleton, A. C. 1981. *Accounting Evolution to 1900*. Tuscaloosa: University of Alabama Press.

Soll, J. 2014. *The Reckoning—Financial Accountability and the Rise and Fall of Nations*. New York: Basic Books.

Wolmar, C. 2001. *Broken Rails: How Privatisation Wrecked Britain's Railways*. London: Aurum Press Ltd.

Chapter

4

Infrastructure Planning and Decision Making

Yet there was one thing that seemed incontrovertible to him out of his experience as head of the Magome Station. This was that of all the coming changes, the ones in transportation and communication would result in the most deep-rooted and substantial transformations of the society. Their effects would be like those of water, the weakest and most subtle but in the end most powerful of all the agents of change. Such changes affected all, high and low, rich and poor. They determined the success or failure of human society.

(Translation by William E. Naff)

— Tōson Shimazaki (1872–1943), a Japanese novelist in the Meiji period. This phrase was spoken by the character Hanzō, a station master of Kiso Road in the book Before the Dawn.

4.1 Investment Plan of Infrastructure

4.1.1 Purpose and Significance of Making an Investment Plan

An investment plan is one of the materials for consensus building between the implementing entity and the stakeholders. Because it sums up the social significance of the infrastructure investment, project plan, amount of investment, and efficiency of investment, an investment plan is fundamental for decision makers. It will be the basis to decide whether to invest and implement a proposed infrastructure concept. In more detail, an investment plan is created with the following purposes:

- Confirmation of social significance: Demonstrate that the investment possesses social significance.
- Confirmation of project plan: Describe the detailed project plan and the amount of investment.
- Evaluation of investment efficiency: Compare the cost with the profit and benefit.
- Identification of key considerations: Examine and demonstrate that there are no serious obstacles to implement the project.

An investment plan is also fundamental for the central or local government to decide whether to use public funds to subsidize infrastructure projects implemented by local governments or private companies. In such cases, an additional purpose of an investment plan for the central or local government is to examine and validate the subsidy for such infrastructure from various viewpoints.

4.1.2 Consensus Building and Decision Making of an Investment Plan

It is vital for decision makers of infrastructure investment to build consensus with stakeholders before making their decisions. There are two types of stakeholders for each investment: those with final decision rights over implementing entities and local stakeholders of the candidate project site.

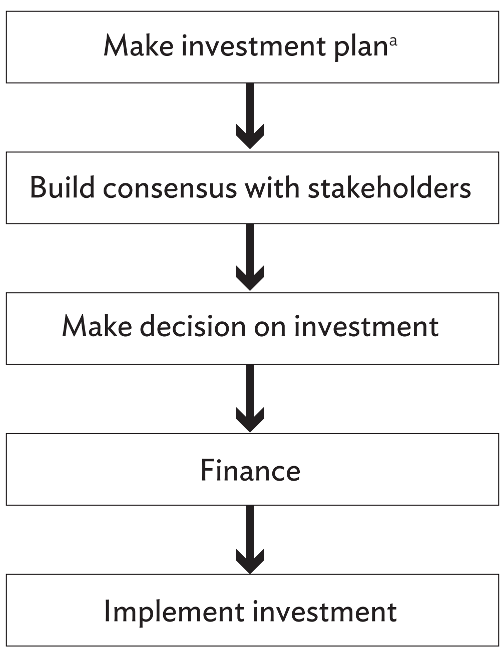
The former type of stakeholders, denoted as "stakeholders with final decision rights," may be shareholders of private companies considering the infrastructure investment. Those of the central or local government are the nations or residents, congress members, and the congress itself.

The latter type of stakeholders, denoted as "stakeholders with great influence on project implementation," are those who will become directly affected by the project. Specifically, they are rights holders of the candidate project site such as land owners and lessees, neighbors, community leaders, and congress members representing them. Note that without special description, we denote "stakeholders with final decision rights" as "stakeholders" for short in this chapter.

In the process of making an investment plan (Figure 4.1), we should emphasize stakeholders' concerns in order to build consensus smoothly. Specifically, investment profitability should be the main issue in private infrastructure investment, because it is shareholders' largest concern. Meanwhile, in public infrastructure projects, we should focus on the improvement of social welfare, the total impact that infrastructure investment brings to the society, economy, and daily life. This is because residents are most interested in that.

After consensus is built with the stakeholders, we can proceed to the next stage of decision making of infrastructure investment. In the case of a private company, decision making of investment proposals is formalized by the resolution of boards of directors. In the case of public entities, it is formalized by the budget approval for the survey,

Figure 4.1: Flow from Making an Investment Plan to Implementing Investment



[a] Includes project evaluation as described later.

Source: Authors.

implementation, or public aids for the project in the related congress (refer to Section 4.6 for details).

Once the infrastructure investment is determined, the project implementing entity will finance the necessary funds, start preparation for construction, and then carry out the investment. This is the official beginning of a project.

4.1.3 Development Process of an Investment Plan

Private goods type projects are evaluated mainly by return on investment upon consensus building. On the other hand, pure public goods type projects are evaluated by economic efficiency and improvement of social welfare. Public–private mixed type projects are evaluated by both of these. Economic efficiency is the comparison of cost and benefit. Benefit is the sum of effects in monetary terms. They are a part that can be monetized in the whole improvement of social welfare.

Therefore, it is important to quantitatively demonstrate in the investment plan how much revenue and benefit the project generates. However, therein lies a big problem. Valuing benefit is very difficult. Under the current technical constraints of evaluation methods, it is not possible to monetize all the effects as benefits. Even benefits, i.e., monetized effects are just monetized under certain assumptions. Therefore, in order to calculate benefit appropriately with the same method under the same assumptions, economic evaluation manuals on benefit valuation of infrastructure define various common assumptions and rules.

4.2 Contents of Investment Plans

The investment plan is the fundamental document decision makers use to make decisions on investment and to build consensus with stakeholders. Based on assumptions of what, why, when, where, who, and how the targeted purpose will be achieved, the implementing entity develops the investment plan with a roughly estimated schedule and cost. This investment plan will be the basis for considering various detailed plans after the investment is determined.

4.2.1 Basic Contents

The basic contents that should be included in the infrastructure investment plan are (i) project significance, (ii) investment contents, (iii) expected effects and impacts, and (iv) items for consideration.

Project significance (i) is the resolution of social problems by the implementation of the project. For projects implemented by private companies, the realization of new revenue opportunities is also important. Investment contents (ii) are details on the methods, the amount of investment, and finance. Expected effects and impacts (iii) are improvement of social welfare generated by operating infrastructure, as well as returns on investment for projects implemented by a private company. Items for consideration (iv) are matters that need to be handled with care upon project implementation, such as the local environment or community involvement.

It is necessary for the implementing entity to consider and clarify each of these items in order to make decisions on the investment. Altogether, the following four elements need to be checked: (i) whether the project has enough significance for stakeholders, (ii) whether its contents (e.g., facility plan, financial plan) are reasonable, (iii) whether the targeted effects can be realized, and (iv) whether it has serious obstacles.

To make reasonable decisions, decision makers must refer to objective evaluation results on each item. For example, to judge whether a project is cost efficient enough, it is necessary to calculate the cost efficiency in quantitative value and compare it with that of alternate or similar projects. This procedure is already done by the implementing entity as they develop the investment plan. Therefore, a part of the project evaluation result is already contained in the investment plan as a basis for decisions. In this sense, it can be said that the investment plan and project evaluation are developed together.

The integration of the investment plan and project evaluation can be accepted without doubt for private enterprise-led projects. However, for public projects (both pure public goods type and public–private mixed type), some explanations are required.

Academic experts may give independent comments on infrastructure investment plans developed by the government. They discuss with government officials regarding matters such as the cost efficiency of the project, its calculation method, assumptions behind it, and comparison with alternative plans. These opinions from third parties can also be regarded as project evaluation. However, note that any new knowledge and opinions for correction at this stage are reflected in the investment plan by the implementing entity itself and therefore will be a target of decision making. Overall, we can say that hearing opinions from third parties at the planning stage constitutes a part of the investment plan development process necessary for social consensus building and decision making of the project.

4.2.2 Similarities and Differences between Investment Plans of Public and Private Projects

As you can easily imagine, the interests of stakeholders differ depending on the implementing entity type, private company or government, and with or without public support.

The intention of investment is the same whether the implementing entity is a private company or government: it is to solve social problems. Yet, these two types have different final goals. The aim of government matches with the interest of residents: to maximize social welfare and economic efficiency through the resolution of social problems. On the other hand, the aim of a private company matches with shareholders: to maximize its profit and corporate value, i.e., stock value.

Under these premises, we describe some details of similarities and differences in investment plans between public and private projects below.

4.2.2.1 Common Contents in Investment Plans for Public and Private Projects

First, the plan should explain the reasons such infrastructure investment is necessary, e.g., background, purpose, and expected effect and influence. Then, the plan should explain what performance is required for the infrastructure under current external factors (performance requirements). Then, the details on methodology to fulfill the requirements, like plan contents, the amount of investment, and the financing methods are explained.

Next, the project evaluation result should be explained to validate the performance requirement and methodology and to make rational investment decisions. For the evaluation, the number of infrastructure users is first estimated by demand forecasting. Then, the number of people affected by the project (including users), in other words beneficiaries, is also estimated. The estimated number of users and beneficiaries will be used in financial and economic evaluation.

For example, in the financial evaluation on a new private railway line, its financial efficiency is based on freight revenues calculated using the estimated number of users. For the economic evaluation of a national highway, its economic efficiency is evaluated using estimated user benefits such as travel time savings and cost reduction. However, regarding flood control infrastructure such as river embankments, we cannot make individual decisions on its usage. Therefore, in this case, demand forecasting is not conducted for economic evaluation. Instead, economic efficiency is evaluated using the estimated damage the levee would prevent, such as flooding of housing and suspended economic activities. The estimation is based on the forecasted number of beneficiaries with property in the flood zone.

Also, the major premises for investment implementation should be explained in the investment plan. A couple of examples are the smoothness of project implementation under current conditions (project implementation environment) and items for consideration for further smooth implementation.

4.2.2.2 Pure Public Goods Type Projects

In the investment plan for a pure public goods type project, its adequacy for tax usage is emphasized for validation to the citizens and local residents who are stakeholders. To be specific, improvement in social welfare and the economic efficiency of the project are emphasized.

Let us look at a case of improving national highways as an example. Since there is no toll collection, the financial efficiency of the project is not an issue from the beginning. On the other hand, the following will be important issues for deciding about highway investment: how much convenience it would bring to users to travel between cities, how much improvement it would bring to social welfare (e.g., resolution of traffic jams, better disaster prevention measures), and economic efficiency, in other words whether its effects are worth the investment. If an unnecessary highway is made, taxpayers would not view this as adequate use of tax and the government would be accused of wasting taxes with severe social criticism. Therefore, in the pre-project evaluation, the necessity, purpose, significance, economic efficiency, and expected improvement in social welfare of the project are all evaluated and deliberated in a committee consisting of academics and experts. For example, in projects led by the Ministry of Land, Infrastructure, Transportation, and Tourism of Japan (MLIT), that committee is called the Project Evaluation Surveillance Committee, and such a committee is established in each regional development bureau of MLIT.

4.2.2.3 Private Business Type Projects

The main purpose of the investment plan of a private business type project is to convince shareholders as stakeholders in the investment. The main interests of shareholders are whether the social problems can be solved, whether profit can be gained, how high the profit will be, and how the investment contributes to increasing corporate value.

For example, executives of a railway company will never invest in a new line if sufficient profit in accord with the amount of investment—

i.e., financial efficiency—is not expected, no matter how much it will increase mobility for residents. If they chose to make an investment with low financial efficiency, they would be severely criticized by shareholders. However, profit is not only estimated from freight revenue, but also from increased profit in related projects and existing businesses such as commercial facilities, hotels, tourism facilities, housing, and real estate in the area. This is called internalization of external effects. Such business models make it possible for many private railway companies in Japan to operate commercially without public subsidy.

4.2.2.4 Public–Private Mix Type Projects

The investment plan of a public–private mix type project has characteristics of both the pure public goods type project and the private business type project. The more public funds are injected, and the more the project affects the lives of residents, the more improvement of social welfare and economic efficiency should be emphasized, in addition to financial efficiency, which is an interest of shareholders.

For example, in the case of a public highway corporation investing in a toll road, its organizational aspect as a private company and its business aspect as a public project will both be regarded as important. When building consensus with its stakeholders, financial efficiency, improvement of social welfare, and economic efficiency will all be discussed to make decisions about the investment.

The basic contents of investment plans explained above can be organized as shown in Table 4.1. Here, the merged sections across projects of the pure public goods type and private business type apply to both types of projects. Projects of the public–private mix type need to consider the contents of the entire table.

4.2.3 Details of Each Type of Content

4.2.3.1 Background and Purpose

This first part of a project plan explains problems the society faces and the social importance of solving them. Then, the investment purpose, which is to solve the problems, will be stated.

4.2.3.2 Performance Target

In this part, the effects and influences targeted and brought by the infrastructure investment are expressed by key performance indicators (KPI). KPIs are a combination of an index and a value that explains

Table 4.1: Contents Described in Infrastructure Investment Plans

Items		Contents of Investment Plan (Example)	
		Pure Public Type	**Private Business Type**
Social Importance	Background and purpose	Describe social problems and its causes that the nation or region faces as background of the infrastructure investment and describe that its objective is to solve them.	
	Performance target	Describe the direct effects and influences through the solution of the social problems above as numerical targets using key performance indicators.	
	External conditions	Describe the external conditions regarding the infrastructure from the point of view of market environment, securing safety, environmental conservation, landscape, history, and culture.	
	Performance requirements	Explain required performance of the infrastructure under the external conditions described above.	
Contents of Investment	Project contents	Explain the basics of facility plan, construction plan, schedule with targeted start of service year, service period (durable years), maintenance management plan, management organization plan, and the like based on the performance requirements.	
	Amount of investment	Estimated total and annual amount of investment (initial cost, running cost)	
	Finance method	Combination of tax revenue, issuance of public bonds, and aid from higher levels of government and other agencies; consideration to apply private finance initiatives; adequate burden sharing of expenses between central, prefectural and local governments, and users[a]	Combination of equity, loan, bond issue, aid, and subsidy; adequate borrowing conditions (amount, period, interest rate, and repayment); possibility of repayment; requirements for subsidy
Project Evaluation	Demand forecast	Estimation of beneficiaries	Pricing and estimation of users
	Financial efficiency		Profitability and level of return on investment. Financial analysis of not only the sole project, but also the integrated projects with related projects and existing projects

continued on next page

Table 4.1 *continued*

Items		Contents of Investment Plan (Example)	
		Pure Public Type	Private Business Type
Project Evaluation	Improvement of social welfare	Describe broad effects and influences of the investment quantitatively or qualitatively	
	Economic efficiency	Describe level of social benefit against investment based on economic analysis	
	Project implementation environment	Describe the current situation of agreement from residents and legal procedures (project implementation feasibility), consistency and relation with higher-order plans or related projects (project policy feasibility), and other aspects of project implementation environment, e.g., technical difficulty.	
Other	Items for consideration	Describe considerations for the area such as countermeasures for project influences on the environment, landscape, history, and culture, contribution to the area, and approaches to build consensus with residents, assuming how the stakeholders with great influence on project implementation perceive it.	
	Other	It is preferable to show the result of alternative evaluation.	

[a] In the case of many types of infrastructure development projects in Japan, burden sharing of expenses between related bodies is fixed as an institution based on the beneficiary pays principle.

Source: Authors.

quantitatively, in some special cases qualitatively, how targeted effects and influences contribute to the solution of the social problems. Examples of KPIs are "X minutes travel time reduction in Y section by relieving traffic congestion," "prevention of flooding from X annual probable rainfall," and "consistently provide sanitary water to all residents in Y area."

A KPI is a clear commitment on the performance target and is used to show the validity of the project in the case that public funds are provided. Therefore, KPIs are checked consistently throughout the plan-do-check-act management cycle of infrastructure investment.

4.2.3.3 External Conditions

In this section, we discuss the external conditions regarding the infrastructure. This is the preparation work to clarify the performance requirements of the infrastructure in the next section, such as service provision, ensuring safety, conservation of the environment, landscape, history, and culture.

Market Environment

To clarify performance requirements of the infrastructure on service provision, the population, industry, current land use, and land use restriction in the relevant area are explained. Then, not only the current conditions and outlook of the targeted infrastructure, but those of other network-linked, complementary, and competing infrastructure are explained.

Ensuring Safety

There are several perspectives regarding safety requirements of the infrastructure, such as its structural safety (including long-term maintenance management against aging deterioration), safety during application, and prevention from large-scale natural disasters.

To clarify safety performance requirements from all the perspectives, safety related elements such as the natural environment (e.g., current state and changes of topography, geology, weather, and sea conditions), potential large-scale natural disasters (e.g., earthquake, tsunami, volcano eruption, windstorm, flood, landslide), and fatigue load are investigated. As for safety during usage in normal times, specifications and standards are often formulated by law or guidelines for each type and characteristic of infrastructure. Therefore, individual special discussion on safety of infrastructure in normal times is unnecessary for many cases at the planning phase.

Possibilities that the infrastructure itself would directly or indirectly affect the safety of users or contribute to damage prevention at a time of disaster should also be considered. For example, at the time of the Great East Japan Earthquake, the Sendai Eastern Road (a toll motorway), which is built on an embankment structure, not only prevented the tsunami from flooding further inland, but also played a role as an evacuation place, thus saving many precious lives. These are not the originally intended function of highways, but it is worth considering adding such ancillary functions in this manner if it is technologically possible and is desired by residents.

Environmental Conservation

To clarify performance requirements regarding environmental conservation, not only the natural environment explained in the section on ensuring safety, but also the current conditions of the atmosphere, water, soil, groundwater level, vegetation, and ecosystem in the area should be explained.

Landscape, History, and Culture

Shared values of the residents such as the landscape must never be destroyed but must be adequately conserved even after the construction of infrastructure. The new infrastructure needs to fit in the local climate and be accepted by the residents. Therefore, landscape, history, culture, community ties, and shared values that the community has conserved with pride should be explained in the investment plan to clarify the performance requirements regarding them. Because physical investigation of the area is often difficult before investment is decided, a literature survey is often done at this stage.

Consideration of archaeological preservation is also very important. In Japan, we need to know if the construction area is a designated buried cultural property. There are about 460,000 sites of buried cultural properties across the nation designated in the Law for the Protection of Cultural Properties. The sites in the region can be checked by inquiring with the local boards of education.

4.2.3.4 Performance Requirements

With external conditions in mind, performance requirements of the infrastructure on such aspects as its service, safety, environment, landscape, history, and culture are clarified.

4.2.3.5 Project Contents

This section explains the contents of the project in relative detail. These details should answer the 5W1H (why, what, when, where, who, and how) of the project, based on the assumed project scale, location, specifications, and method of construction. Specifically, abstracts of the facility plan and construction plan are developed. An abstract of the overall schedule with the targeted start of service and interim milestones should be included in both plans. The overall schedule developed at this stage will also be the basis of more detailed calculation after the implementation is decided.

The service period (durable years) will also be predetermined. A rough maintenance management plan and a management organization plan, which are necessary to keep infrastructure functioning and satisfy its performance requirements, are also set.

4.2.3.6 Investment Expenditure

First, the initial annual cost (design and construction cost) and running cost (operation and maintenance management cost) of the infrastructure is roughly estimated. By summing up these annual costs, the total investment expenditure can be estimated. These roughly estimated annual costs will be the basis of more detailed calculation after implementation is decided.

4.2.3.7 Finance

This section explains how to finance the investment expenditure. National and local government tax revenue, issuance of public bonds, and aid from higher levels of governments and other agencies are combined to finance the project for pure public goods type projects. In some cases, utilizing the private finance initiative (PFI), public projects implemented, financed, and operated by private enterprises, is also considered. The adequate burden sharing of expenses between the central government, prefectural governments, local governments, and users should be discussed.

The implementing entity's own funds, loans from governmental and non-governmental financial institutions, corporate bonds, government aid, and interest subsidies are combined to finance private business type projects. On such an occasion, the adequacy of debt conditions such as amount, period, interest rate, and repayment of the loan should be carefully assessed for each lender. If corporate finance is difficult, project finance is considered. Corporate finance is raising funds with the implementation entity's trust or estate as collateral, whereas project finance is raising funds with the cash flow generated by the project as collateral.

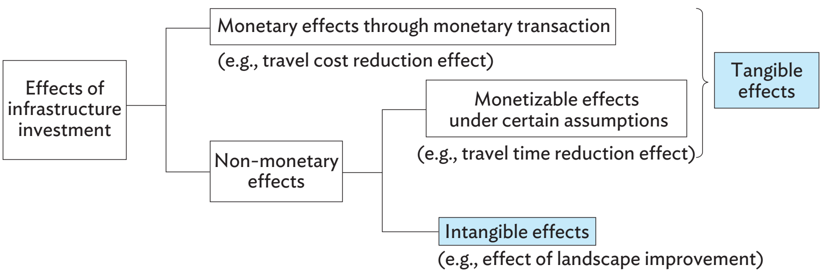
4.2.3.8 Project Evaluation

This section explains the effects and influences the infrastructure investment is expected to have according to the plan above. Also, three fundamental premises of implementation are explained. They are project implementation feasibility (agreement from residents and smooth process of legal procedures), project policy feasibility (consistency and relationship with higher-order plans or related projects), and project implementation environment (e.g., technical difficulty). Finally, the comprehensive project evaluation based on these premises is explained.

Project evaluation consists of three parts. One is financial evaluation, an evaluation of the revenue and expenditure of the implementing entity. Another is economic evaluation, an evaluation of the social effects and influences that are tangible and can be monetized. The last is comprehensive evaluation. The target of comprehensive evaluation includes the project implementation environment as well as intangible effects and influences (Figure 4.2), which are difficult to monetize under existing benefit-evaluation technology. Figure 4.3 shows the targeted range for each part of the evaluation.

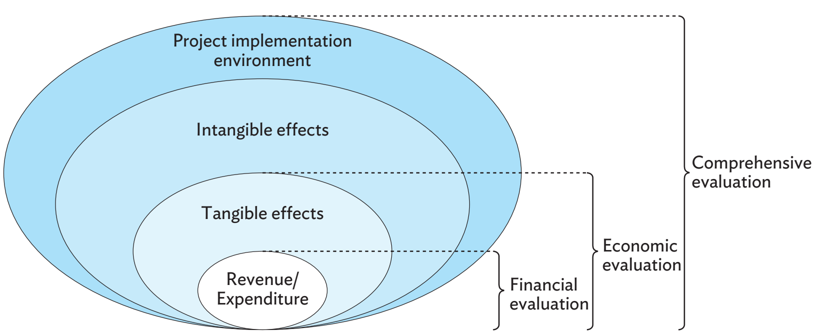
Financial evaluation and economic analysis will be explained in detail in Section 4.3. Comprehensive evaluation will be explained in Section 4.4.

Figure 4.2: Tangible Effects and Intangible Effects



Source: Authors.

Figure 4.3: Effects Included in Financial, Economic, and Comprehensive Evaluation



Source: Authors.

4.2.3.9 Items for Consideration

This section is on matters that need special attention. One particularly important matter is considerations for the area so that project implementers and local residents can reach consensus on the infrastructure development. They need to be based on assumptions of how stakeholders perceive it. Considerations for the area could include countermeasures of project influence on the environment, landscape, history, and culture, contribution to the area in various methods, and approaches to build consensus with residents smoothly. Details on items for consideration, which differ depending on stakeholders' perception of the investment, will be explained in Section 4.5.

4.2.3.10 Additional Information

For smooth consensus building and decision making, it is preferable to compare evaluation results with other alternative plans such as plans with different technology, and optimal plans from the standpoint of each stakeholder's concern. The evaluation of alternatives will be discussed in Section 4.3.

4.3 Financial Evaluation and Economic Analysis

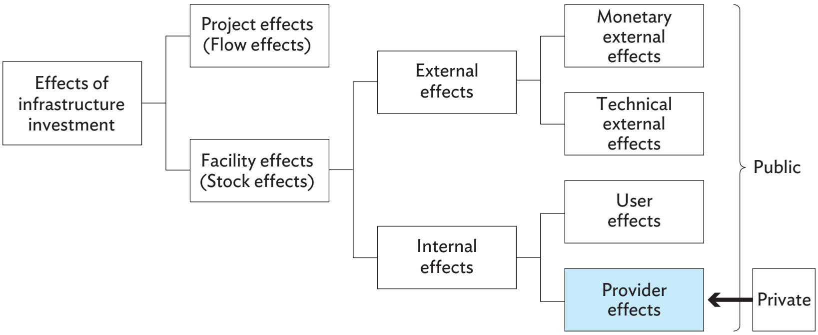
This section will discuss financial and economic evaluation for tangible effects. Their role in project evaluation is to help make an appropriate judgment and decision on infrastructure investment.

4.3.1 Basic Concept

4.3.1.2 Effects of Infrastructure Investment and Views from Public and Private Sectors

In the project evaluation of infrastructure investment, the element that affects investment judgment most is usually investment effects. However, the contents of investment effects vary greatly depending on factors such as the type of infrastructure, implementing entity, and characteristics of the construction site. Therefore, there have been many attempts to classify and systematize it so far. In this book, we will explain the classification of investment effects roughly as shown in Figure 4.4, considering it important that infrastructure implementation entities are recently diversifying, mainly from the public to the private sector.

Figure 4.4: Classification of Effects of Infrastructure Investment and Public and Private Viewpoints



Source: Authors.

Project Effects and Facility Effects

Investment effects consist of project effects and facility effects. Project effects are economic impacts caused by the monetary flow due to the investment during the infrastructure development process (e.g., construction), and facility effects are economic impacts due to usage of the facility in service. Project effect is a collective term for successive economic activities such as materials purchased for bridge construction or salary payment to construction workers. It is also called flow effect or economic multiplied effect. Any monetary flow causes instant project effects even if construction is not yet completed. On the contrary, after infrastructure is completed and monetary flow stops, project effects will decline drastically.

Since a facility effect is caused by usage of the infrastructure in service, it is also called a stock effect. Facility effects can be classified into internal and external effects.

Internal Effects and External Effects

Internal effects appear in the service market directly targeted by infrastructure investment. Let us take a railway line construction project as an example. Internal effects could include travel time reduction for railway users (user effect) and profit to the railway company (provider effect) in the transportation service market.

External effects appear out of the targeted service market. In the case of highway interchange construction, the increase of land prices (housing and real estate market) in areas with improved accessibility is considered as an external effect.

External effects consist of monetary external effects and technical external effects. In the case of a new railway development project, land price increase near its stations is a typical monetary external effect. Land prices increase because of development profit, a reflection into the land market of train users' consumer surplus (valuation of mobility improvement minus transportation fee). A typical technical external effect is environmental improvement such as reduction in noise, vibration, and air pollution (NOx, etc.) along the existing roads as a result of car users changing to use the new railway. On the other hand, there can be negative effects (influences) such as noise and vibration disruption along the new railway line. Blocking sunlight by a viaduct development would also be included in negative effects. However, if the implementing entity compensates the residents for such negative external effects, these external effects will be internalized and appropriated as negative provider effects on the account of the implementing entity.

Difference between Viewpoints from Public and Private Sectors
The merit of classifying the effects of infrastructure investment, as shown in Figure 4.4, is that the difference between the public and private sector viewpoints on investment evaluation is easy to understand.

For private business type projects, financial evaluation focusing on monetary profit and expenditure is the main issue among all the provider effects. For example, if a private railway company and its group companies attempt to take in positive effects from related and existing projects such as the development of commercial facilities near the railway station, it can be considered an internalization of external effects to the entire group of companies. They can expand the scope of evaluation to the entire project group and consolidate financial evaluations to include some external effects of related and existing projects internalized as provider effects.

For pure public goods type projects, evaluation is mainly based on improvement in social welfare. It considers as wide a range as possible of effects and influences. This includes conducting not only financial evaluation (chargeable infrastructure only) and economic analysis, which consider tangible effects, but also comprehensive evaluation that considers intangible effects and the project implementation environment.

4.3.1.2 Evaluation Principles

The following contents are common principles to evaluate an investment plan, whether it is a pure public goods type, private business type, or public–private mixed type project.

With-Without Comparison

The evaluation of infrastructure investment is conducted not by before-after comparison, but by with-without comparison.

Let us consider a new bypass highway construction project as an example. If it is developed, traffic jams are expected to be reduced and rush hour will be shorter. However, if it is not developed, traffic jams will be worse and rush hour will be longer. Evaluation by before-after comparison for this investment cannot take this worsening of traffic jams into account. In other words, the value of this project would be underestimated. For adequate evaluation, with-without comparison should be conducted at certain points in the future. Comparison should be conducted both for traffic conditions and expenditure with and without project development.

Evaluation in Monetary Value

Not all effects and influences of infrastructure investment can be clearly assigned a monetary value like fee income. However, in order to evaluate the economic efficiency of infrastructure investment, it is necessary to compare and evaluate effects and influences in the same measure as investment expenditure, which is monetarily expressed. Therefore, certain assumptions are necessary to monetize the effects and influences of infrastructure investment and evaluate them as benefits.

Evaluation in Present Value

Infrastructure investment generates revenue and expenditure streams over a long period of time. Therefore, one point in time is set as the base point (usually a point when evaluation is conducted) and then monetary streams of revenue, expenditure, and benefits of each year are converted into value in terms of the base point.

For infrastructure investments implemented by private companies, the implementation entity conducts business with funds raised through equity or loans from financial institutions. Such funds require financial costs (required dividends or borrowing interest) until all are repaid. Let us assume the financial cost as an annual interest rate r = 5%. Financed funds of x = \$100 million requires repayment of x = \$100 million at present, but it will be increased to $x \times (1+r)$ = \$105 million in the next year. In other words, the current \$100 million is worth \$105 million 1 year later. Conversely, x = \$100 million next year currently has the value of only $x/1(1+r) = 100/105 \fallingdotseq$ \$95 million. The current funds have more value than those in the future, and this is called time preference.

As explained, the value of current funds after 1 year can be calculated with $1/(1+r)$. Value after n years can be calculated with $1/(1+r)^n$. Financial cost r is also called the discount rate, and $1/(1+r)$ is called the discount factor. Value in the future divided by the discount rate is called present value, and its computation process is called capitalization.

Since the implementing entity finances funds by various methods, the average of the financial cost of all methods should be used as discount rate r. To be specific, the weighted average cost of capital (WACC) is used as discount rate r, calculated as the weighted average of finance cost r_i (i: financing method) with financing ratio of fund (debt and equity) w_i. This can be expressed by the following equation:

$$r = WACC = \sum_{i=1}^{n} w_i r_i \text{ (n: the number of financing method types)}$$

Benefits, or monetized influences and effects, must be also be capitalized, just like revenue and expenditure. There are several reasons the idea of time preference is introduced even to benefit evaluation. However, the easiest one to understand is this. No one can say for sure that they will be alive in the future, even a month or a year later. Therefore, there is always a possibility that you cannot receive the benefit that is generated in the future. Benefits that anyone can surely receive have more value than uncertain benefits in the future.

The problem here is how to determine the discount ratio used in the capitalization of benefits. Revenue and expenditure are results of direct monetary transactions between the implementing entity and other entities such as users. However, benefits are received by numerous and varied entities, and some are not generated through monetary transactions. Therefore, benefits cannot be capitalized using a discount rate like WACC. It is necessary to use a social discount rate that reflects social time preference instead of individual time preference.

Although there are several theories on how to determine the social discount rate, in practice, the market interest rate (or social opportunity cost rate), the risk-free rate of return, is used as the social discount rate. The interest rate of long-term government bonds can be considered as the quasi-market interest rate. In Japan, the market interest rate is set referring to the 10-year net yield of government bonds.

If the social discount rate is overestimated, benefits in the future will be underestimated, and the infrastructure investment that otherwise would have been implemented may not be. On the contrary, if the social discount rate is underestimated, its benefit will be overestimated, and infrastructure investment that is not worth implementing may be implemented. Recently, the 10-year net yield of Japanese government bonds tends to decline. However, the social discount rate of 4% determined officially by the former Ministry of Transport in 1999 is still used today (2019) even though the financial situation in Japan is very severe.

There is also a proposal that the social discount rate to evaluate the effects of environmental quality improvement such as the reduction of carbon dioxide emissions should be smaller, because such effects will be generated successively over a long period of time.

Finally, it must be noted that different discount rates are applied for financial evaluation and economic evaluation. So even if expenditure and social expense are the same in nominal terms, they will have different present values.

Avoidance of Double Count

Infrastructure investment may generate not only targeted effects and influences, but also secondary effects on the regional and global environment (technical external effects). Moreover, indirect effects in the market of other goods and services may be induced by direct effects (monetary external effects). Monetary external effects can cause a chain reaction of other monetary external effects.

There are two types of benefit evaluation methods, depending on which end of the chain you start with, namely incremental benefits-based evaluation or incidence-based evaluation. Currently, most social benefits are evaluated based on the origin because it is easier under the present evaluation technology.

Monetary external effect at some point in the succession includes not only direct effects but also monetary external effects of the preceding succession. Therefore, the same effect may be counted twice if you simply sum up direct effects and monetary external effects. This double count may result in the overestimation of benefits. To prevent this, you should be careful not to sum up direct effects and monetary external effects together. On the other hand, direct effects and technical external effects do not overlap, and it is okay to sum up these two effects.

Let us consider investment in highway development connecting an agricultural production place and its distant consumption place as example. In this case, you can observe agricultural production prices at consuming areas dropping and consumers being able to buy them at cheaper prices. Let us analyze this investment effect from origin to incidence focusing on transportation cost.

With the development of the highway, travel time from the agricultural production place to the consumption place will be reduced. Consequently, the labor cost of drivers will be reduced (travel time reduction benefit). Fuel consumption costs will also be less due to the shorter transport distance and faster travel speed (travel cost reduction benefit). Both benefits are incremental benefits and will result in cheaper transportation costs. Some or all of the reduced cost will be reflected in cheaper purchasing costs for retailers, and then in cheaper retail prices. In other words, some or all incremental benefits generated by highway development (travel time reduction and travel cost reduction benefits) are reflected in incidence-based benefits (cheaper products for consumers) through reductions in transportation cost, purchasing cost, and retail price. Therefore, the same benefit will be counted many times if you sum up incremental benefits and benefits at each point in the succession.

Sometimes, benefits are evaluated in an incidence-based way, depending on the characteristics of the project. For example, land readjustment projects and urban redevelopment projects generate various internal and external effects. In these projects, benefits are evaluated by the hedonic approach using change in residential land prices, based on a certain assumption that all the effects will finally result in the rise of land prices (capitalization hypothesis). The cost–benefit analysis manual of these projects by the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) in Japan states that benefit should be evaluated by the incidence-based hedonic approach.

Evaluation Period

No infrastructure functions forever. Even if it is maintained appropriately according to the maintenance plan, infrastructure deteriorates from physical and chemical external forces. The physically durable years of any infrastructure are limited. Because the infrastructure investment plan will be evaluated before the actual implementation, the service period—that is, the period of project implementation (construction period) plus the physically durable years—will be the evaluation period. To be specific, standard evaluation periods in Japan are the construction period plus 40 years for road development projects, the construction period plus 50 years for river and dam development projects, the construction period plus 50 years for harbor and airport development projects, and the construction period plus 30 or 50 years[8] for railway development project projects.

---

8 The reason why either 30 or 50 years can be applied as the service period of railway development projects in Japan is described in The Manual for the Evaluation Method of Railway Projects. "The service period should be determined by durable years. However, this manual allows 30 or 50 years to be applied as the standard service period because (1) 30 years is conventionally used as the evaluation period in financial evaluation of railway development projects; (2) Due to the current improvement of technical durability, facility components with more than 50 durable years have increased; (3) Benefits of the evaluation period from 31st to 50th year can be estimated to a certain extent by interpolating the benefit calculation results of the 30th and 50th years. In any case, the service period of the project should be determined appropriately, taking project lifecycle into consideration." In this way, the evaluation period is now in the process of trial and error, trying to make it based on the actual durability of facilities in this era of infrastructure innovation.

Life Cycle Cost

The assumed expenditure in the investment plan valuation is its life cycle cost (LCC). LCC is the total of initial cost, cost of operation, maintenance, major repairs, and disposal and replacement.

4.3.2 Demand Forecast

The starting point of financial and economic evaluation is forecasting demand to predict the number of future infrastructure users. The number of users for regional monopolistic infrastructure (electricity, gas, water and sewerage system, etc.) is relatively easy to estimate based on the population and household projection in the infrastructure-affected area. However, in case of arterial roads and such, the number of users depends not only on the amount of travel demand between its connecting areas, but also on travel time, toll rate, and existence of alternative travel modes. Therefore, complicated models must be used to estimate the number of users for these projects.

To estimate the annual number of users during the evaluation period, you should determine exogenous future scenarios on the index that affects the number of users, such as population or the growth rate of gross domestic product (GDP). Since the number of users for chargeable infrastructure also depends on its charge rate (elasticity of demand to price), charge setting and demand forecast should be conducted together.

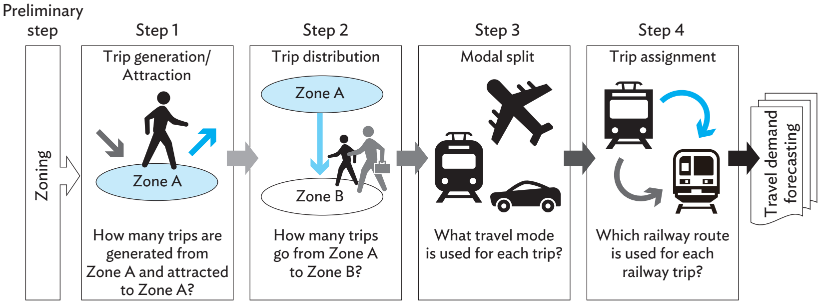
4.3.2.1 Determination of Future Scenarios

We develop a future scenario with the necessary exogenous variables to forecast the number of infrastructure users. The variables include the population and economic growth rate (GDP growth rate) of the region. Variables necessary for forecasting demand depend on the type of infrastructure.

For example, a four-step model (Figure 4.5) is used practically for the demand forecast of a transportation project. This model subdivides the process of demand forecasting into steps. First, it forecasts trip generation (total number of trips by all modes per year all over the country). Then, it forecasts total trips from each origin and total trips to each destination zone (trip generation/attraction), forecasts trips between each pair of origins and destinations (trip distribution, or origin–destination trip matrix), forecasts trips by each travel mode (modal split), and finally forecasts trips by each route (trip assignment). By dividing trip production proportionately in this stepwise manner, the number of users of the transportation project can be forecasted. It is common that trip production, the basis of the demand forecast,

Figure 4.5: Four-Step Model

Preliminary step: "Zoning" to divide the target area into units called zones
Step 1: Forecasting trip generation from each zone and trip attraction to each zone
Step 2: Forecasting trip distribution between each origin zone and each destination zone
Step 3: Modal split of each inter-zone trip into each alternative travel mode
Step 4: Trip assignment of each inter-zone trip of each travel mode to each alternative travel route



Source: Railway Technical Research Institute. 2010. *Demand Forecasting for Railway Passengers 2010*. Tokyo.

is estimated by a regression formula with the total population and economic growth rate as explanatory variables. Therefore, it is necessary to base a future scenario on the total population and economic growth rate during the evaluation period. For the total population in Japan, a 50-year projection published[9] by the National Institute of Population and Social Security Research called "Population Projection for Japan (medium-fertility assumption and medium-mortality assumption)" is often used. As for the economic growth rate, "Economic and Fiscal Projections for Medium to Long Term Analysis" by the Cabinet Office is often used.

As for electricity, gas, and water and sewerage, to estimate the number of users, we base a future scenario on factors like the total population, the number of households, and the number of workers in the service supply area. Since service supply area does not always match with administrative district, a cohort analysis is necessary in some cases to determine the future population and the number of households. That is, we estimate the population in the district based on social and natural increase and decrease of the population in each age group. A future scenario on the number of workers is determined according to assumptions about the future trends of industry.

---

[9] The population for the next 50 years (100 years in total) is also estimated and published as a reference for analysis of long-term population projections.

4.3.2.2 Charge Setting

As for chargeable infrastructure projects, the number of users depends very much on the rate of charges. So, the charge setting is very important to estimate the number of users. However, as explained in Section 3.4, the charge rates of infrastructure are often regulated. Therefore, the implementing entity cannot always set the rate so as to maximize its profit. In that case, the rate is set according to the rate calculation formula based on the regulation or referring to the rate of existing similar type infrastructure.

4.3.2.3 Estimation of the Number of Users and Beneficiaries

The estimation methods of the number of users and beneficiaries are developed for each type of infrastructure, taking various characteristics into account.

For example, the number of main transportation users will be practically estimated by the four-step model explained above. There, the number of users for other transportation facilities and routes are estimated integrally. For electricity, gas, and water and sewerage, consumption intensities (unit value), e.g., the amount of daily consumption per capita, will be set for each usage (living, commercial, industrial, etc.) based on actual past consumption. The future consumption amount is estimated by multiplying the consumption intensities with the forecasted population, number of households, laborers, and trends of industry in the service supply area.

4.3.3 Financial Evaluation

As explained above, an investment plan of a private company is evaluated mainly on its profitability. Profitability is calculated from annual expenditure and revenue.

Annual revenue can be estimated from the rate of charges and the number of users determined by the demand forecast. By converting them into present value using a discount rate (weighted average cost of capital, or WACC) and then summing them up, the total revenue can be estimated in present value.

You can also estimate total expenditure in present value in a similar manner. Annual expenditure such as initial investment, maintenance and management costs, and major repair costs are converted into present value using the discount rate and then added up over the evaluation period.

The evaluation of the investment profitability will be based on financial analysis with total revenue and expenditure estimated as above.

4.3.3.1 Financial Analysis

The total revenue and expenditure in present value is calculated using the following equations. T is the evaluation period (years). R_t and C_t, are the annual revenue and expenditure of the project in the t^{th} year, respectively. The first year is the base point in time. r is the discount rate (WACC) of the implementing entity.

Present value of the total revenue:

$$R = \sum_{t=1}^{T} \frac{R_t}{(1+r)^{t-1}}$$

Present value of the total expenditure:

$$C = \sum_{t=1}^{T} \frac{C_t}{(1+r)^{t-1}}$$

Net present value (NPV) can be calculated as the difference between total revenue and total expenditure in present value. The discount rate is the WACC of the implementing entity.

$$NPV = R - C = \sum_{t=1}^{T} \frac{R_t}{(1+r)^{t-1}} - \sum_{t=1}^{T} \frac{C_t}{(1+r)^{t-1}} = \sum_{t=1}^{T} \frac{R_t - C_t}{(1+r)^{t-1}}$$

The discount rate, different from WACC, but the one such that total revenue equals to total expenditure, i.e., NPV = 0, is called the financial internal rate of return (FIRR) r'.

$$\sum_{t=1}^{T} \frac{R_t}{(1+r')^{t-1}} = \sum_{t=1}^{T} \frac{C_t}{(1+r')^{t-1}}$$

One sample calculation of NPV and FIRR is shown in Table 4.2. There is no analytical equation or closed-form solution to calculate FIRR, but it can be easily calculated with Microsoft Excel or a high-functioning calculator. In financial evaluation, not only the analysis result of the infrastructure project in question but also the consolidated analysis result of simultaneously implemented projects (commercial, residential, etc.) as a group are taken into consideration.

Table 4.2: Calculation Example of NPV and FIRR

(Rate of return r=5%)

Year	1	2	3	4	5		28	29	30		Total
Annual Revenue (Rt)	0	0	30	40	50		50	50	50	Total Revenue (R)=	1,370
Annual Expenditure (Ct)	150	100	2	2	2		2	2	10	Total Expenditure (C)=	330
Annual BoP (Rt–Ct)	–150	–100	28	38	48		48	48	40	Total BoP (R–C)=	1,040
Annual Revenue (Rt in PV)	0.0	0.0	27.2	34.6	41.1		13.4	12.8	12.1	Total Revenue (R) in PV=	682.66
Annual Expenditure (Ct) in PV	150.0	95.2	1.8	1.7	1.6		0.5	0.5	2.4	Total Expenditure (C) in PV=	283.88
Annual Expenditure (Rt–Ct) in PV	–150	–95.2	25.4	32.8	39.5		12.9	12.2	9.7	NPV=	398.8
										FIRR=	10.1%

BoP = balance of payment, FIRR = financial internal rate of return, NPV = net present value, PV = present value.

Source: Authors.

4.3.3.2 Financial Investment Criteria

To have the infrastructure investment approved from a financial point of view, criteria of NPV and FIRR both need to be satisfied (Table 4.3). Fortunately, these two are in an equivalent relationship, i.e., the satisfaction of one criterion will automatically lead to satisfaction of the other.

FIRR is a very important criterion in private business projects. This is because FIRR is independent from the project scale and is easy to

Table 4.3: Investment Criteria for Profitability

Index	Calculation	Criteria (Threshold)
NPV	Free cashflow in present value (PV) (NPV = revenue in PV – expenditure in PV)	NPV is positive (NPV>0)
FIRR	The discount rate that total revenue in PV equals to total expenditure in PV	FIRR is larger than discount rate (WACC) (FIRR>WACC)

FIRR = financial internal rate of return, NPV = net present value, PV = present value, WACC = weighted average cost of capital.

Source: Authors.

compare with financial cost (WACC). Some companies set their own required rate of return as a hurdle rate for investment. At the time of this writing, hurdle rates are around 5% for companies that use WACC as a reference, 7–8% for companies with highly profitable projects, and 10–12% for some foreign-capitalized companies.

Of course, future revenue and expenditure are estimated based on uncertain factors. Therefore, it is necessary to check the robustness of financial analysis results beforehand using sensitivity analysis.

4.3.3.3 Sensitivity Analysis and Records of Hypothesis and Assumptions

Since the infrastructure investment plan involves many uncertainties during the planning stage, values of various parameters are set based on hypothesis and assumptions. Some examples are external conditions that affect performance requirements, schedule, expenditure, charge rate, and the number of users. Of course, the values that the planners consider most likely are set. However, the set values cannot help involving uncertainty, and true values often differ from set values. Note that it is impossible to have only one parameter set differently from its true value in practice. Rather, it is more likely that almost all the values of parameters are different from their true values.

Therefore, it is important to understand beforehand how much profitability will be affected by influential parameters. This process to check the robustness of evaluation results is called sensitivity analysis. The sensitivity analysis result will be one of materials for decision making on the investment.

There are two methods of sensitivity analysis, based on whether only one value of influential parameters is changed at a time (others are fixed) or all main parameters are changed simultaneously (Table 4.4). In practice, the former method is often used (Figure 4.6). In particular, the influence on profitability of a plus-or-minus 10% change in the number of users is frequently identified. Break-even point analysis to find the value of the parameters that makes profitability zero is also very common.

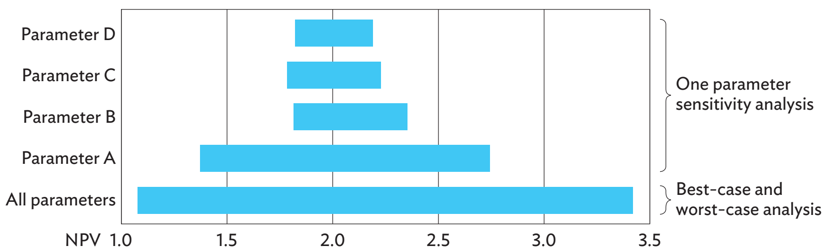
All values of parameters, their hypothesis and assumptions, and their rate of change in sensitivity analysis should be recorded with their evidence or background ideas. These records will be helpful in factor analysis if the project does not go as it was initially planned. They are also valuable for future similar infrastructure investments to set the hypothesis, assumption, or figures.

Table 4.4: Methods of Sensitivity Analysis

Methods of Sensitivity Analysis	Outline of Method	Output
One parameter sensitivity analysis	Focusing on value of only one of the main parameters (e.g., initial cost, start of service year, charge rate), check the effect of analysis results in the case of a certain rate (e.g., +/−10%) or amount of change of its value.	The range of analysis results in the case of change of only one parameter value, i.e., the effect of change of the parameter value.
Best-case and worst-case analysis	Changing values of all the main parameters, set the values that make the analysis result the most favorable (best-case scenario) and the most unfavorable (worst-case scenario) and check the range of the analysis results.	The possible range of analysis results in the case of changing values of all the main parameters

Source: Ministry of Land, Infrastructure, Transport, and Tourism.

Figure 4.6: Example of One Parameter Sensitivity Analysis and Best-Case and Worst-Case Analysis



NPV = net present value.

Source: Ministry of Land, Infrastructure, Transportation, and Tourism. 2009. *Technical Guidelines on Cost Benefit Analysis for Public Project Evaluation (Common Set)*. Tokyo.

4.3.3.4 Alternative Evaluation

While considering the investment plan, many other alternative plans that also meet the performance requirements of the infrastructure will be compared with it. Some alternative plans have a different site, scale, position, structure, or construction method and so on; some may have a different construction process, such as step-by-step development, observing an uncertain number of users through partial service provision. For smooth consensus building, it is important for planners to sincerely consider and propose optimal alternative plans for decision makers and stakeholders from the standpoint of their matter of concern. Stakeholders in this case means not only the ones with final decision rights but also includes the ones with great influence on project implementation (especially possible opposing entities).

However, it is difficult and inefficient for planners to draft every alternative plan and compare them with each other due to limited resources (budget, staff, time). Therefore, during the earlier stage of drafting alternative plans, they are roughly considered and compared, and plans that appear to be inferior are excluded. The remaining ones will be further considered and brushed up.

Then, all the alternative plans are compared qualitatively from various viewpoints such as effectiveness in the solution of social problems, technical difficulty, expenditure, and acceptance from residents. The pros and cons of each plan are clarified and evaluated, and the best plan will be selected as the final plan to use in further considering the detailed investment plan.

The significance of alternative evaluation is to create clear evidence why the final plan is selected through the comparison of alternative plans, to make the decision-making process more transparent, and to identify issues for further consideration such as disadvantages of the final plan against other alternative plans.

4.3.3.5 Consideration for Subsidy Acquisition

It is not always appropriate to abandon an infrastructure investment plan only because it does not satisfy the investment criteria of financial analysis. If the economic analysis indicates the infrastructure investment plan will have large social and economic significance, subsidies or tax benefits from national and local governments or low-interest loans from government financial institutions may be available.

If subsidies are acquired, the implementing entity can reduce its expenditure. If a low-interest loan is secured, it will reduce the financial cost of the infrastructure (WACC) and make the discount rate for financial analysis smaller. Both will lead to increased NPV of the infrastructure investment and lower the threshold of FIRR for investment criteria (WACC). Then, the investment plan may satisfy the financial investment criteria.

Of course, subsidies and interest subsidies of low-interest loans from governmental institutions are public burdens. However, the change of the burden ratio will not affect the result of economic analysis, as explained later. As long as the infrastructure investment is approved socially and economically in economic analysis, the financial analysis result for the implementing entity can be improved through a change in the burden ratio by the acquisition of subsidies or low-interest loans.

4.3.4 Economic Evaluation

4.3.4.1 Evaluation of Project Effects (Flow Effects)

Project effects (flow effects) are computed by input–output analysis. This concept will be explained using a simplified input–output table.

The input–output table shows the volume of business between industrial sectors. The most simplified example for two sectors, i.e., the construction sector and other sectors, is shown in Table 4.5 (transaction base table) and Table 4.6 (input coefficient table). The columns in the transaction base table show the composition of necessary expenditure for intermediate input to produce goods and services in each sector (raw material expenditure, etc.). In the case of the construction sector, ¥10 billion and ¥5 billion is input into the construction sector and other sectors, respectively, to produce construction products worth ¥25 billion (such as 10 kilometers of highway). Ten billion yen is gross value added such as the income of workers and operating surplus. The rows show the sales total of products (goods and services). In the example of the construction sector, ¥10 billion worth of construction products are sold to the construction sector and other sectors, respectively, as intermediate demand and construction products worth ¥50 billion are sold as final demand. The input coefficient table shows input value divided by production value of each sector in each row. This is basically the expenditure composition of 1 unit of production in each sector. In this case, 0.4 units of construction products and 0.2 units of other sectors' products are input to produce 1 unit of construction products.

Table 4.5: Transaction Base Table

(¥ billion)		Intermediate Demand: Construction	Intermediate Demand: Other	Final Demand F	Output X
Intermediate Input	Construction	100	100	50	250
Intermediate Input	Other	50	150	300	500
Gross Value Added		100	250		
Output		250	500		

Source: Authors.

Table 4.6: Input Coefficient Table

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2">Intermediate Demand A</th></tr>
<tr><th>Construction</th><th>Other</th></tr>
<tr><td rowspan="2">Intermediate Input</td><td>Construction</td><td>$0.4\left(=\frac{100}{250}\right)$</td><td>$0.2\left(=\frac{100}{500}\right)$</td></tr>
<tr><td>Other</td><td>$0.2\left(=\frac{50}{250}\right)$</td><td>$0.3\left(=\frac{150}{500}\right)$</td></tr>
<tr><td colspan="2">Gross Value Added</td><td>$0.4\left(=\frac{100}{250}\right)$</td><td>$0.5\left(=\frac{100}{500}\right)$</td></tr>
<tr><td colspan="2">Output</td><td>$1.0\left(=\frac{300}{300}\right)$</td><td>$1.0\left(=\frac{500}{500}\right)$</td></tr>
</table>

Source: Authors.

Now, let us consider how much products of each sector will increase if 1 unit of final demand in the construction sector is generated. One unit of construction products itself will be generated, of course (direct effect). According to the input coefficient table, 0.4 units and 0.2 units will be newly input into the construction sector and other sectors, respectively, as intermediate input (first indirect effect). Then, this 0.4-unit and 0.2-unit production increase in each sector will further increase production in each sector (second indirect effect). Successive indirect effects expressed by input coefficients are organized into the inverse matrix coefficient table (Table 4.7).

Table 4.7: Inverse Matrix Coefficient Table

	Construction	Other
Construction	1.842	0.526
Other	0.526	1.579
Row sum	2.368	2.105

Source: Authors.

We will explain why this table is called the inverse matrix coefficient table. We take the 2×2 matrix of intermediate input and demand in Table 4.6 as matrix A, and the column vectors of final demand and production sales in Table 4.5 as F and X, respectively. To be specific,

$$A = \begin{pmatrix} 0.4 & 0.2 \\ 0.2 & 0.3 \end{pmatrix} \quad F = \begin{pmatrix} 50 \\ 300 \end{pmatrix} \quad X = \begin{pmatrix} 250 \\ 500 \end{pmatrix}$$

Two rows on intermediate input in Table 4.5 can be expressed as follows.

$$AX + F = X$$

Let us solve this equation for X.

$$X - AX = F$$
$$(I - A)X = F$$
$$X = (I - A)^{-1}F$$

Here, I is identity matrix $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$ and $(I - A)^{-1}$ is the inverse matrix of $(I - A)$.

If $F = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$, X will be $X = (I - A)^{-1}$. Therefore, this inverse matrix shows how many units of new products will be generated in each sector when demand for each sector increases by 1 unit. This is the reason why Table 4.7 is called the inverse matrix coefficient table.

Actual calculation of $(I - A)^{-1}$ is as follows.

$$(I - A)^{-1} = \left(\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - \begin{pmatrix} 0.4 & 0.2 \\ 0.2 & 0.3 \end{pmatrix} \right)^{-1} = \begin{pmatrix} 0.6 & -0.2 \\ -0.2 & 0.7 \end{pmatrix}^{-1}$$
$$= \frac{1}{0.6 \times 0.7 - (-0.2) \times (-0.2)} \begin{pmatrix} 0.7 & 0.2 \\ 0.2 & 0.6 \end{pmatrix} = \begin{pmatrix} 1.842 & 0.526 \\ 0.526 & 1.579 \end{pmatrix}$$

This result is the same as the 2×2 matrix shown in Table 4.7.

By using this inverse matrix coefficient table, we can see that a 1-unit demand increase in the construction sector and other sectors creates an increase of 2.368 units and 2.105 units respectively for the whole industry, including the 1-unit direct effect.

Based on this idea, input–output analysis is the method to calculate production-induced effects.

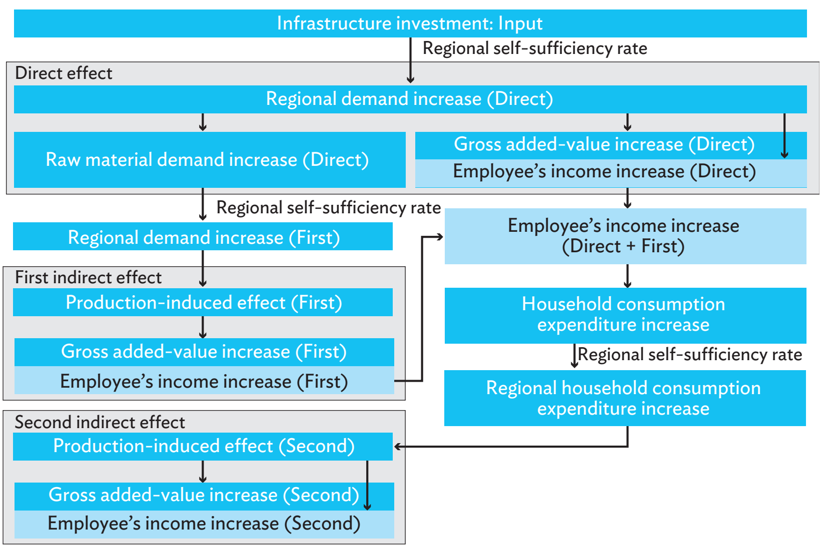
The input amount for each sector P (vector) multiplied with the inverse matrix coefficient $(I - A)^{-1}$ results in a production-induced effect from the investment. There is also a labor coefficient, not shown in the example above, which shows the necessary amount of labor for each sector when demand for each sector increases by 1 unit. Labor coefficients are used to calculate the employment-generation effects of the infrastructure investment.

Different input–output tables are used depending on the scale of project effects (flow effects). We use a national input–output table to compute the effect on the whole country, and a local one to compute the effect on the local economy.

Moreover, input–output tables with different levels of sectorial classification are used according to the intended use. For example, in Japan, there are four types of national input–output tables with industries classified into 13, 37, 105, or 184 sectors. The economic impact of infrastructure investment is usually analyzed using the investment amount input of the construction sector, which is a large classification. Therefore, a detailed input–output table is usually not necessary, and the one with 37 sectors is enough.

The input–output analysis process for project effects (flow effects) is shown in Figure 4.7.

Figure 4.7: Calculation Process of Project Effects (Flow Effects)



Source: Yamaguchi Prefecture.

4.3.4.2 Evaluation of Individual Facility Effect (Stock Effect)

The economic efficiency of infrastructure investment is calculated using annual expenditure and benefits. The method for calculating benefits differs greatly depending on the characteristics of the infrastructure and targeting effects and influences.

Benefits show themselves in various ways. Some can be easily evaluated in monetary value, but others are intangible effects and are difficult to include in economic evaluation as they are. Therefore, there have been many attempts to evaluate intangible effects in monetary value.

As for transport infrastructure projects, e.g., a bypass road alternative to a frequently congested road, the effect of travel time reduction is evaluated by introducing the idea of "time value." Time value literally means the monetary value of time per hour. There are many proposed methods to compute time value. In Japan, it is hypothetical revenue in the case that time reduced was allotted to production. This method is called the preference approach.

If a public facility like a park is constructed, some residents near it who had been using an existing facility far from them will benefit from time reduction. This benefit can also be calculated by time value. This method is called the travel cost method.

Under current benefit evaluation technology, time-based tangible effects only up to this level can be included to total benefit in cost-benefit analysis, which was explained in Section 4.3 above.

As for river levee development, the direct targeted effect is reduction of damage due to natural disasters. To evaluate the benefit, flood simulations with and without levees are first conducted. Then, the estimated number of damaged houses, area of flooded farmland, and so on are multiplied with the unit cost (average restoration cost per house, per area, etc.). The result of the calculation is how much damage will be reduced by the levee. This method is called the unit cost method (UCM).

Some emotional effects include improvement of comfort by new parks and riverfronts, improvement of safety by fewer traffic accidents due to road improvement, and improvement of security by disaster prevention measures. Since these effects are only emotional, it is difficult to evaluate them as benefits in monetary value. One method that solves the problem is a questionnaire to ask how much people would be willing to pay for the benefit (willingness to pay). For example, we ask questions like, "How much are you willing to pay for a new park that will make your life more comfortable?" This method is called the contingent valuation method, and it is one of the methods to monetize effects not traded in the market as benefits.

The methods explained above are all incremental methods of benefit evaluation, but there are also incidence-based methods to evaluate all the various effects generated by an infrastructure development in a lump sum. For the example of a land readjustment project, which generates various tangible and intangible benefits, it is common to evaluate them in a lump sum by the change of land price, i.e., the incidence-based hedonic approach based on the capitalization hypothesis explained in the discussion of avoidance of double count in Section 4.3.1.2.

Some are skeptical regarding the accuracy of these methods. However, on building social consensus for infrastructure investment, monetization of intangible effects is useful. Therefore, improvement of accuracy and reliability for each method is keenly desired.

4.3.4.3 Economic Analysis

The annual benefit of each effect is first summed up into annual benefit B_i. B_i is then converted into present value using social discount rate r and summed up over the evaluation period. This procedure to calculate total benefit B can be expressed by the following equation.

$$B = \sum_{t=1}^{T} \frac{B_t}{(1+r)^{t-1}}$$

Likewise, total expenditure C can be expressed by the following equation. C_t is the annual expenditure, which is the sum of initial investment, operating cost, maintenance and management cost, large repair cost, and other costs in each year.

$$C = \sum_{t=1}^{T} \frac{C_t}{(1+r)^{t-1}}$$

Total expenditure and total benefit computed here will be used to evaluate economic efficiency in economic analysis.

Net present value (NPV) is the difference between total benefit B and total expenditure C, both in present value.

$$NPV = B - C$$

Cost–benefit ratio (CBR) is total benefit divided by total expenditure.

$$CBR = B/C$$

Economic internal rate of return (EIRR) is a newly computed discount rate *r'* that makes total benefit *B* match total expenditure *C*.

$$\sum_{t=1}^{T} \frac{B_t}{(1+r')^{t-1}} = \sum_{t=1}^{T} \frac{C_t}{(1+r')^{t-1}}$$

Like FIRR, EIRR can also be calculated easily with Microsoft Excel or a high-functioning calculator.

4.3.4.4 Economic Investment Criteria

Whether the project is worth investing in is evaluated by economic analysis. To have infrastructure investment approved from social and economic points of view, all the criteria of NPV, CBR, and EIRR need to be satisfied, as shown in Table 4.8.

Table 4.8: Investment Criteria for Economic Efficiency (Economic Analysis)

Index	Calculation	Investment Criteria (Threshold)
Net Present Value (NPV)	Difference between benefit and cost in present value (NPV=B−C)	NPV is positive (NPV>0)
Cost–Benefit Ratio (CBR)	Ratio of benefit to cost (CBR=B/C)	CBR is larger than 1 (CBR>1)
Economic Internal Rate of Return (EIRR)	Discount rate that makes benefit match cost	EIRR is larger than social discount rate (SDR) (EIRR>SDR)

Source: Authors.

However, these three are in an equivalent relationship to each other. That is, satisfaction of one criterion automatically leads to satisfaction of the other two criteria. Also, both NPV and CBR are calculated with the social discount rate, but it is difficult to derive that rate precisely. There lies the significance of using EIRR as an economic investment criterion that can be calculated without the social discount rate.

Future benefit and expenditure are, of course, estimated with uncertain factors. Therefore, as explained below, it is necessary to check the robustness of the economic analysis result beforehand using sensitivity analysis.

4.3.4.5 Sensitivity Analysis and Record of Hypothesis and Assumptions

Whether the economic efficiency of the project is worth investing in even considering the risk of an uncertain implementation environment is evaluated by sensitivity analysis. Like the sensitivity analysis explained in Section 4.3.3.3, it is important to understand how much economic efficiency will be affected by the uncertainty of its main factors. The robustness of the economic analysis result will be one of the materials for decision making on the investment.

All the values, their hypothesis and assumptions, and their rate of change in sensitivity analysis should be recorded with their evidence or background ideas.

4.3.4.6 Risk Evaluation

If the economic efficiency of the investment is evaluated to be unstable by sensitivity analysis, planners must enhance the project's robustness against the main uncertain factors. This can be done by prescribing countermeasures against those factors or revising and modifying some project contents. See Chapter 6 for details on risk regarding an infrastructure project.

4.3.4.7 Alternative Evaluation

After various alternative plans based on different assumptions, each satisfying the performance requirement, are compared and considered, the best will be selected as the final plan. Alternatives to project implementation methods are also discussed at this stage. One example of a project implementation method is a PFI, which reduces the total expenditure and financial burden on the public by introducing private finance. At last, only the final plan will be further discussed in detail.

In Japan, the public planners of projects under the jurisdiction of MLIT have been required since FY2012 to conduct alternative evaluation at the planning stage.

4.3.5 Concerns

4.3.5.1 Evaluation According to the Requirement of the Times

Evaluation of public investment is a tool for building consensus with stakeholders (the people and residents). Therefore, the evaluation method and its system should reflect the diverse sense of values of the citizens and local residents. Sense of values is influenced by social background, social system, social problems, and also technical trends at the time. Thus, the evaluation method and its system should be revised to keep up with the times if necessary. In practice, evaluation methods and important evaluation items have changed in the past. This varies from country to country.

For example, prosperous socio-economic activities in Japan created much demand for infrastructure during times of high economic growth. Public investment with a limited budget could not keep up with this increasing demand, and rapid expansion of infrastructure was the pressing task, leaving off evaluation or consensus building. Because of the success of rapid economic growth, the people trusted national and local governments on infrastructure investment decision making. Even after the oil crisis and the revelation of pollution problems, complete reliance regarding infrastructure investment did not waver, though people's consciousness toward the environment and economic growth had changed. Therefore, the project evaluation method in Japan was immature. To be accurate, there were some projects that evaluated parts of their effects quantitatively. However, most of them focused only on emphasizing a variety of effects and influences, either qualitatively or quantitatively.

In the late 1990s, the Japanese economy suffered from the collapse of the economic bubble. As the depression continued, criticism about "unnecessary public projects" mounted among the citizens. The criticism was mainly about the lack of evaluation of economic efficiency. Therefore, in 1997, then Prime Minister Ryūtarō Hashimoto ordered the government to introduce a re-evaluation system on public projects. From then on, manuals of cost–benefit analysis were organized and published according to project type, and evaluation of the economic efficiency of investments was widely carried out. Evaluation of the economic efficiency of investments by cost–benefit analysis is particularly easy to understand because its calculation result is shown as a clear quantitative value and its socio-economic criteria of investment are theoretically clear. Also, as large debts of national and local governments are increasingly acknowledged, criteria of economic efficiency contribute to the restoration of fiscal health. Due to these two reasons, the economic efficiency of investments calculated by cost–benefit analysis became the main evaluation item for public investments.

Lately, infrastructure projects are evaluated by broad effects and influences, economic efficiency of investment, and the project implementation environment in a well-balanced manner.

Outside Japan, there have been advanced attempts in New Zealand regarding the project evaluation system of public investments. Previously, there was high social demand for infrastructure development in New Zealand, so much that the government under financial difficulty could not handle it all. To solve this problem, they decided to select projects based on economic efficiency. To be specific, infrastructure was invested in the order of high cost–benefit ratio (B/C). The lowest cost-benefit ratio B/C of implemented projects at that time was about 3 to 4. Therefore, evaluation techniques were aggressively developed and modified to include various types of effects in benefits. The infrastructure investment evaluation techniques of New Zealand influenced those of Japan. Considering the technical limitations of benefit evaluation, comprehensive evaluation that includes various intangible effects and influences is currently adopted in New Zealand, on the assumption that the cost–benefit ratio is larger than 1.

As for the evaluation of road development projects in England and France, comprehensive evaluation including various intangible effects and influences has been adopted. Therefore, it recently became possible to select projects even with a cost–benefit ratio smaller than 1. In England, projects are evaluated focusing on employment-generating effect, tax-revenue increasing effect, or regional economic impact because the high unemployment rate has become a social problem in the country.

4.3.5.2 Technical Limitations of Economic Evaluation (Cost–Benefit Analysis)

Much infrastructure is developed with large investments funded by governments' tax revenue collected from citizens. Of course, governments must make the most of the limited budget for the people and must use the budget to generate the greatest results (effects) within its limitations. If one infrastructure project is invested in, there are always other projects (other infrastructure projects, and projects in other fields such as education, welfare, or national defense) that were not implemented due to budget constraints. If it would have been more valuable for the people to implement those not-implemented projects, it cannot be said that the budget was efficiently used. Therefore, comparing and evaluating every cross-cutting project is the ideal in deciding the truly most efficient use of the budget.

The current most useful evaluation measurement is economic evaluation based on cost–benefit analysis. However, many evaluation items are difficult to evaluate as benefits under current evaluation techniques. The evaluation accuracy of benefits also varies greatly among types of evaluation items. Therefore, it is difficult to compare even projects in the same infrastructure area, such as a bypass road development project and an underground installation of power lines along roads. Comparison of projects is nearly impossible in different fields, like a bypass road development project, a project to promote information and communication technology (ICT) in education, a nursing home development project, purchasing fighter jets and the like. However, it is possible to evaluate and compare two projects of the same type, such as between two bypass road development projects or between two underground installations of power lines, based on the result of the economic analysis (cost–benefit ratio, etc.).

As explained above, there are some types of infrastructure for which it is difficult to evaluate their main targeted effects. Others may be evaluated only partially or with low accuracy under current evaluation techniques. Therefore, the limitations of current evaluation techniques should be clearly identified. Also, the presence of effects that are not yet evaluated in the economic analysis should be taken into consideration when the infrastructure projects are evaluated on economic efficiency.

For example, imagine an infrastructure investment with main targeted effects that are difficult to evaluate in monetary value, though the facility is apparently needed by the society. When only the monetizable effects and influences are evaluated, its evaluation result will be low and below the criteria (threshold) for implementation. Should we evaluate this infrastructure investment as inefficient with only this result?

The fact that benefit evaluation of effects is technically difficult does not mean that such effects do not exist. However, evaluating investment efficiency only based on an economic analysis result is equal to stating that these effects do not exist. If an infrastructure investment truly needed by the society is not implemented, that itself is a social loss. Therefore, the result of efficiency evaluation based on economic analysis should not be seen as absolute, but only as one of the checkpoints on the aspect of efficiency, with its limitation in mind.

4.3.5.3 Objectivity, Reasonability, and Fairness of Evaluation, and Transparency of Decision-Making Process

It is important to provide precise and necessary information on public investments to taxpayers and residents as stakeholders, in order to obtain their understanding. To achieve this, objectivity, reasonability, and fairness of evaluation must be secured with scientific methods.

Also, the transparency of the decision-making process must be ensured. In Japan, evaluation methods of effects, influences, and economic efficiency are explained on the websites of MLIT, the Ministry of Agriculture, Fisheries, and Food (MAFF), the Ministry of Economy, Trade, and Industry (METI), and the Ministry of Health, Labor, and Welfare (MHLW). On their websites, not only are the rules and detailed evaluation manuals for each type of project published, but also an abstract of each project's evaluation results is disclosed. Therefore, the people and residents are nominally able to check the evaluation results of each project. However, for ordinary people without expert knowledge, it is difficult to understand the effects, influences, and economic efficiency of the project and then make their own judgment and produce their own opinions. Therefore, projects are usually also discussed in council or committees consisting of experts before implementation.

4.4 Comprehensive Evaluation

Among all investment evaluation methods, this section will explain comprehensive evaluation, which also includes intangible effects and influences and the project implementation environment.

4.4.1 Multi-Criteria Evaluation

Opinions on the most important factor regarding public infrastructure projects vary among people. Some think economic efficiency and adequacy as tax usage is the most important, but some think effectivity in solving social problems is more important. Others may give importance to preserving the environment, landscape, history, and culture.

The project implementation environment also cannot be ignored, whether it is a public or private project. A project without a satisfactory implementation environment cannot be conducted even with impeccable financial or economic evaluation results. Project implementation environment here refers to technical difficulty, consensus building with stakeholders, and obtaining understanding and cooperation from residents.

Therefore, all infrastructure investments must also be evaluated by multiple criteria that take both the consciousness of stakeholders and implementation environment into account. There are two methods of evaluation using multiple criteria, as shown in Table 4.9. Out of the two, comprehensive evaluation is explained in the following.

Table 4.9: Methods of Multi-Criteria Evaluation

Multi-Criteria Evaluation	Description
Organized presentation of evaluation results	Supports stakeholders and decision makers in comprehensively deciding whether to implement an investment to present all the evaluation results in an organized format such as standard table form.
Cost–Benefit Ratio (CBR)	Supports stakeholders and decision makers to comprehensively decide whether to implement an investment with a comprehensive evaluation score calculated with scores (e.g., 1–5) of all the evaluation items multiplied by weight according to significance (weighted sum or weighted average).

Source: Authors.

4.4.2 Methods of Comprehensive Evaluation

In comprehensive evaluation, the targeted evaluation items and their categories are first clarified and systemized. Next comes consideration of how to set an evaluation index for each item, how to score all indexes consistently, and how to weight each category according to its significance.

4.4.2.1 Clarification of Evaluation System

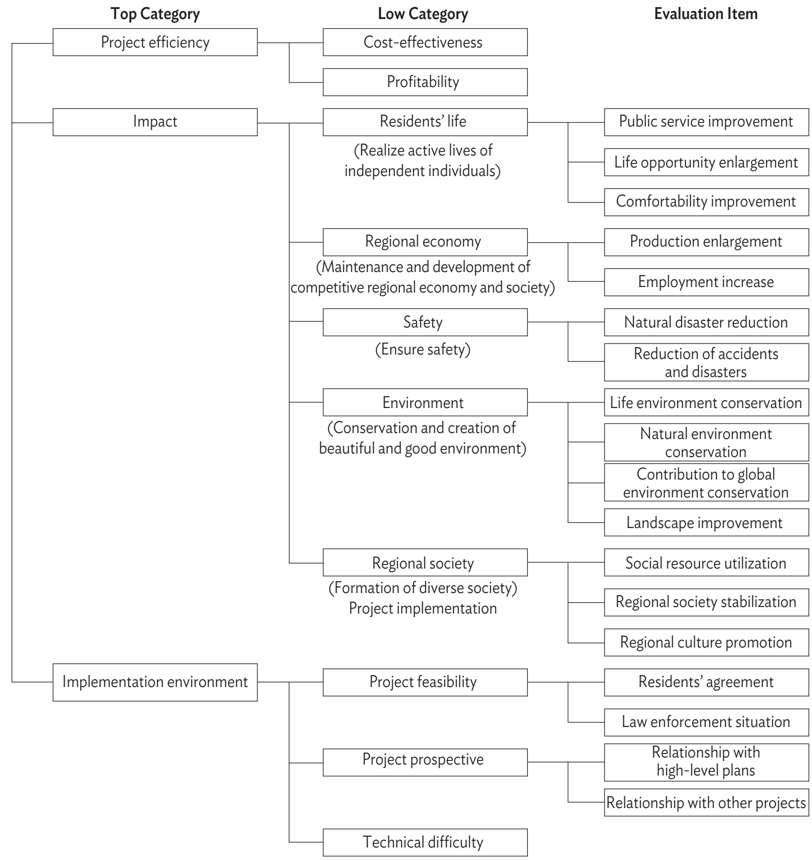
Targeted evaluation items and their categories are first organized hierarchically and systematically. One example of evaluation category systemization is shown in Figure 4.8. Evaluation items are ones in the lowest class, and an evaluating index is set for each one of them. Anything in the upper hierarchy is called an evaluation category. In this chapter, we will refer to evaluation items and categories as just "evaluation categories" for short. A superordinate category should cover all subordinate categories within its range. Also, the abstraction level of categories in the same hierarchy should be the same throughout the whole evaluation system.

4.4.2.2 Setting of Evaluation Index

An index that most easily and accurately expresses the effect and influence of the project should be set as an evaluation index.

Let us take a road development project as an example. "Reduction of natural disaster damage" is an evaluation item. Indexes for this item are such things as whether roads can prevent fire spreading in densely populated districts (over 25 m width) and whether roads can act as an evacuation site in case of natural disasters like earthquakes (with wide

Figure 4.8: Example of Evaluation System



Source: Ministry of Land, Infrastructure, Transport, and Tourism.

green belts). (Roads over 25 meters in width are known to generally prevent fire from spreading, and wide green belts beside roads can be used as evacuation sites during emergencies.) It is possible to set several indexes for one evaluation item. However, we must note that the item will weigh over twice as much as an item with one index. You should carefully consider and modify this problem, for example, by readjusting weight between items.

4.4.2.3 Scoring Each Evaluation Item

Each evaluation item should be scored by a consistent scale with a set of evaluation criteria and reference points. The scoring system should be easy for anyone to understand, like a simple 5-point scale.

Evaluation Criteria

By setting evaluation criteria, an evaluation category score will be able to correspond to changes made by infrastructure development. An evaluation category with tangible indexes is easy to score. However, for some evaluation categories, it is difficult to set tangible indexes. The level of effect in these categories can be expressed with qualitative descriptions like very large, large, medium, small, or very small. The number of applicable changes from the infrastructure development in a full list of expected changes are also used to quantify the effect.

Setting Reference Points

In order to set evaluation criteria, it is important to clarify how reference points are set. There are two situations to which reference points (for example, 3 points) can be set. One is the situation before the project implementation. The other is the minimum effect that should be accomplished by the project.

In the example of a road development project above, the evaluation item “reduction of natural disaster damage” is not the targeted effect originally. Therefore, it would be acceptable to treat the situation the same as before, and allocate the reference point accordingly (3 points). If the road can both prevent fire spreading and act as an evacuation site in the case of emergencies, then this category will be given 5 points. If only one of the two effects can be achieved, then 4 points, and if neither effect can be expected, 3 points.

4.4.2.4 Weighting Evaluation Categories

Weighting Using the Analytic Hierarchy Process

Each evaluation category is weighed based on assumptions about its importance for the stakeholders and decision makers. However, directly setting the weight is difficult especially when there are many indexes. One of more objective weighting methods is the analytic hierarchy process (AHP).

In AHP, evaluation items are first compared and assigned weights among other items under the same upper category according to the pairwise comparison method, which will be explained in the next paragraph. (In Figure 4.8, agreement of residents and law enforcement progress are compared with each other.) Upper evaluation categories are also compared and assigned weights within the same hierarchy. (In Figure 4.8, three categories in the middle hierarchy, which are project feasibility, project prospective, and technical difficulty under the present implementation environment, are compared with each other. The same can be said for the three categories in the highest hierarchy, which are project efficiency, impact, and implementation environment.) Then, the weight of each item can be calculated by multiplying with the weights of its upper categories. For example, the weight of "Residents' agreement" in the third layer can be calculated by multiplying the weights of "Project feasibility" in the second layer, "Implementation environment" in the top layer, and itself within the layer.

Calculation of Weights by the Pairwise Comparison Method

In the pairwise comparison method, we define which item is how much more important for every pair of evaluation categories using qualitative descriptions like "same," "a little important," "important," "very important," and "absolutely important." How many times more important one category is than the other can be calculated based on these qualitative significances in values (pairwise comparison value).

Let us calculate the weight of project efficiency, project impact, and implementation environment in the highest hierarchy as an example. First, we assign 1 for "same," 3 for "a little important," 5 for "important," 7 for "very important," and 9 for "absolutely important." Next, we compare all the pairs of evaluation categories one by one. In this case, we define project impact as "important" (five times more value) against project efficiency, project implementation environment as "absolutely important" (nine times more value) against project efficiency, and implementation environment as "a little important" (three times more value) against project impact. As for the reversed pairs, the qualitative significance will be an inverse number. For example, project efficiency will be evaluated one-third times as important as project impact. The item or category against itself is "same" and the value will be 1.

For all the pairs, the significance x_{ij} of category i compared with category j can be organized as in the pairwise comparison table in Table 4.10.

Table 4.10: Example of a Pairwise Comparison Table

j \ *i*	**Project Efficiency**	**Impact**	**Implementation Environment**
Project Efficiency	1	1/5	1/9
Impact	5	1	1/3
Implementation Environment	9	3	1

Source: Authors.

Matrix X with pairwise comparison value x_{ij} as elements is called a pairwise comparison matrix.

$$X = \begin{pmatrix} 1 & 1/5 & 1/9 \\ 5 & 1 & 1/3 \\ 9 & 3 & 1 \end{pmatrix}$$

Weights of project efficiency, project impact, and implementation environment can be calculated as follows. First, each geometric average (radical root) is calculated. Then, the geometric averages are normalized to make the sum 1 (Table 4.11).

Table 4.11: Example of Weight Calculation for Each Evaluation Category

j \ *i*	Project Efficiency	Impact	Implementation Environment	Geometric Average	Weight
Project Efficiency	1	1/5	1/9	$\sqrt[3]{1 \times 1/5 \times 1/9} = 0.281$	$0.281 / 4.467 = 0.063$
Impact	5	1	1/3	$\sqrt[3]{5 \times 1 \times 1/3} = 1.186$	$1.186 / 4.467 = 0.265$
Implementation Environment	9	3	1	$\sqrt[3]{9 \times 3 \times 1} = 3.000$	$3.000 / 4.467 = 0.672$
			Total	**4.467**	**1.000**

Source: Authors.

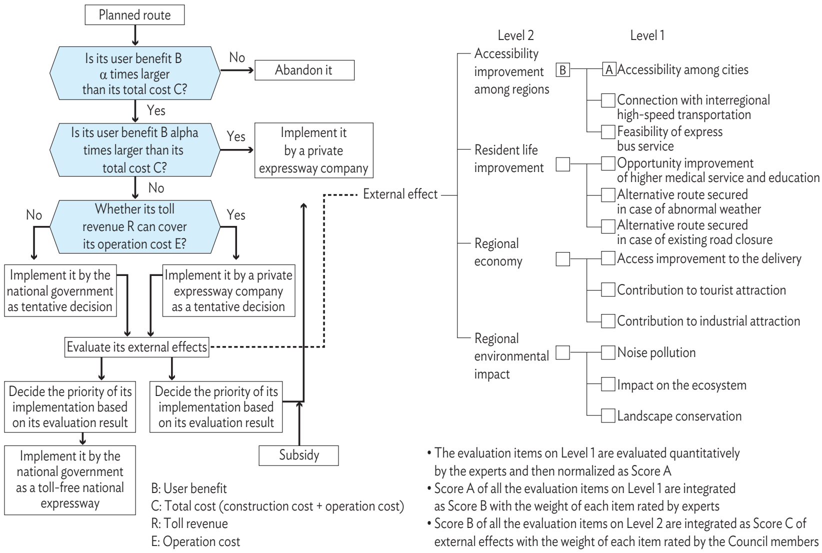
This method using geometric averages assumes that there are errors in pairwise comparison values, and thus minimizes the error by the logarithmic least squares approach. There is also a weight calculation method using eigenvectors of the pairwise comparison matrix. If there are three evaluation categories (in the case that the pairwise comparison matrix is three-dimensional), it is well-known that the eigenvectors match the geometric averages.

4.4.2.5 Calculation of the Comprehensive Evaluation Point

After weight w_i and evaluation point s_i are set for each evaluation category i, then a comprehensive evaluation point can be calculated as their weighted sum.

Comprehensive evaluation point $\sum_{i=1}^{n} w_i \cdot s_j$.

Figure 4.9: Example of Comprehensive Evaluation Applied at the Time of Privatization of Highway Public Corporations



Source: Ministry of Land, Infrastructure, Transport, and Tourism.

4.4.3 Example of Comprehensive Evaluation

In new expressway (limited access road) development projects, comprehensive evaluation was used to evaluate external effects to decide which road sections will be operated by the National Expressway Companies (NEXCO) as toll roads and which sections will be operated by the government as free expressways. The flow chart of this case is shown in Figure 4.9. In this case, whether the implementing entity will be NEXCO (private project) or the government (under jurisdiction of MLIT) is first temporarily decided by economic and financial evaluation results. Then, according to the comprehensive evaluation result on external effects, the order of project priority is decided. Projects with high priority (priority projects) will be implemented by NEXCO with subsidies from the government (public–private mixed type infrastructure). Others will be implemented by the government as additional implementing projects and will be free expressways (pure public goods type).

The following are explanations of Figure 4.9.

In this example, new expressways are evaluated in four steps.

(i) Evaluate the user benefit and check whether it is at least α times (threshold) larger than the project expenditure C. The implementing entity invests only in road sections with $B/C \geqq \alpha$. $\alpha=1$ was applied for this case, but it is possible to apply $\alpha=0.8$ like in France as a threshold.

(ii) Evaluate the revenue R of the implementation entity and check if it is larger than the project expenditure C. If $R/C \geqq 1$, then NEXCO proceeds with the project as a private project. If $R-C \leqq 0$, then either NEXCO proceeds with the project with government involvement or the government itself becomes the implementing entity.

(iii) In the case that revenue R of the implementation entity is not enough ($R-C<0$), then check if R is larger than the operating cost of the expressway E. If $R/E \geqq 1$, then NEXCO proceeds with the project with government subsidy (initial subsidy provision type among the private project types). If $R/E<1$, then the government will implement the project as a free expressway (pure public goods type).

(iv) Evaluate external effects for each road section. All multiple evaluation categories should be evaluated integrally by their weighted averages. Based on this evaluation result, the priority order of road sections for project implementation is decided.

External effects consist of four level 2 effects as shown in Figure 4.9. Each of the four effects, namely improvement of connection between areas, improvement of quality of life in the area, improvement of area economy, and influences on area environment, consists of three level 1 effects. Each level 1 effect is evaluated on a scale of 1 to 5 by experts. Their weighted sum is the point for their level 2 category. To decide the weight of each of the level 1 effects, several experts allocate a total of 10 points to level 1 effects under each level 2 category. To decide the weight of each level 2 effect, a total of 10 points is also distributed among all level 2 categories. Several representatives from different standpoints distribute the points to be fair. The highest and lowest weights are excluded before calculating the average weight, because they can be extreme values. The comprehensive evaluation value of external effects is the weighted sum of the level 2 effects.

This evaluation method may be considered non-scientific and subjective because the weights of each of the effects are based only on evaluators' opinions without pairwise comparison like previously explained. However, this should be allowed as one way of comprehensively evaluating effects and influences when a unified evaluation scale cannot be used. Similar methods are often used and generally accepted in society, such as in school entrance examinations, where grades of different subjects are integrated to evaluate.

4.5 Consensus Building with the Local Stakeholders

4.5.1 Consensus Building with the Local Stakeholders

It is fundamental to build consensus with the local stakeholders in order to maximize social welfare (objective of pure public goods type projects) and/or profit (objective of private business type projects) through the solution of problems by infrastructure investment.

Infrastructure is basically built to improve the social welfare of the local community. Therefore, communities should generally welcome it. However, even if it is a must-have facility for the community, neighboring residents whose daily life will be directly affected by it cannot welcome it whole-heartedly. This is because their living environment may be damaged and property value may decrease. Sewage plants and waste management facilities are especially opposed due to their psychological and environmental influences, but even transportation facilities like railways, highways, and ports are not welcomed in general. These are called NIMBY (not-in-my-back-yard) facilities.

Upon development of these types of infrastructure, it is necessary for the implementing entity to have close and continuous communication with local residents from the early stages. It may be necessary to change its structure or operation to deal with the residents' concerns. In some cases, consolation facilities like parks are constructed to compensate for the feeling of dislike and overcome difficult consensus building.

Even for investment in non-NIMBY infrastructure, it is necessary for the implementing entity to take appropriate measures to preserve the environment, landscape, history, and culture, and to contribute to the area. The measures should consider the concerns of stakeholders with great influence on project implementation.

The environment, landscape, history, and culture are often formed through various processes and are treasured as a shared value within each community. Therefore, a single technical measure to preserve them is not enough. The implementing entity should acknowledge local community ties, shared value, and the community history based on literature surveys and interviews. Then the implementing entity should seek to build consensus with residents by holding workshops and having close communication with them. Understanding local opinions and reflecting them adequately in the design is important not only for smooth consensus building, but also for getting local residents to later cherish the infrastructure as their shared value.

Considering recent severe criticisms of infrastructure development projects and the rapid spread of personal opinions through social media, it is becoming increasingly important to include appropriate considerations for the local residents.

If the implementing entity is a private company, adequate considerations for the community can result in not only smooth project implementation but also an increase in corporate reputation and corporate value.

4.5.2 Consensus Building with Authorities

To implement an infrastructure investment, the implementing entity often must obtain various statutory permissions or approvals from the government (ministers) or local governments (governors). The permissions are to ensure adequate project implementation and orderly development, and to minimize negative influences on residents' lives. For example, a private company must obtain permission from the governor as stated in the City Planning Act before altering the zoning, shape, or quality of land over a certain scale for private infrastructure development. For infrastructure development where farmland is being converted for site acquisition, the implementing entity must obtain permission from the prefectural governor or mayor of the designated municipality as stated in the Agricultural Land Act. For infrastructure development with reclamation, they must obtain permission from the governor as stated in the Act on Reclamation of Publicly Owned Water Surfaces. Likewise, in the case of railway business, the implementing entity needs to obtain a license from the Minister of Land, Infrastructure, Transportation, and Tourism as stated in the Railway Business Act.

Although objective requirements for permission and approval are defined, there sometimes exists room for the discretion of the department to judge whether the infrastructure satisfies the requirements. Therefore, the screening process for permission or approval can be lengthy. It also depends on the policy trends of the national or local government in charge. For example, municipalities with a high priority on the conservation of the natural environment may not approve large-scale infrastructure development that changes the natural environment dramatically, even if it satisfies the requirements for permission or approval.

To smoothly obtain permission or approval, the implementing entity needs to understand related policy trends and consult with the department in charge from the early stages. They must also make an explanation to the department and seek their understanding on the details of the investment such as its objectives, significance, effectivity to solve the social problems, and expected effects backed up by evidence. If the implementing entity reaches broad agreement with the department to obtain permission or approval from the early stages, later they will only have to consider detailed requirements. Also, the department may propose various ideas to help the infrastructure satisfy the requirements.

4.6 Decision Making on Project Investment

4.6.1 Decision Making by the Implementing Entity

4.6.1.1 Decision Making in Private Companies

In a private company, the planning staff in charge of the infrastructure investment draws up the investment plan. In many cases, they will also serve as an intermediary to coordinate various departments within the company, such as the project department in charge of land acquisition, operation, and maintenance, and the corporate department in charge of management planning and public relations. For smooth decision making and implementation of the project, the planning staff should get related departments to understand the contents of the investment plan and revise it based on opinions from other departments if necessary.

A draft of the investment plan is first reflected in the management plan and then combined into the budget. The budget (the investment plan) will be discussed and decided by the board of directors.

4.6.1.2 Decision Making in the Government

Decision Making on the Investment Plan

Previously in Japan, long-term infrastructure development plans such as the Five-Year Road Development Plan had been formulated and consistently promoted in nine project areas, including roads, rivers, ports, and airports. However, these long-term plans have received the criticism that vertically-segmented planning impedes mutual collaboration, that plans lack flexibility in budget allocation, and that plans are no more than a means of acquiring funding.

To deal with these criticisms, the Act on Priority Plan for Infrastructure Development was enacted in 2003. This act integrates individual long-term plans into one 5-year period plan, the Priority Plan for Infrastructure Development. This plan clarifies which project areas of infrastructure will be prioritized from which viewpoint, or the direction of infrastructure investment during the period. At the point of writing this book, the most recent plan is the Fourth Priority Plan for Infrastructure Development with the plan period 2015–2020.

Major planning matters described in the plan are priority objectives regarding the implementation of infrastructure development projects, an overview of the infrastructure development projects that should be implemented in order to accomplish the priority objectives, and measures for implementing the infrastructure development projects in an effective and efficient manner. There, the expected outcomes of the infrastructure development projects are set as key performance indicators (KPIs) instead of the total amount of future project expenditure.

Furthermore, a regional priority plan for infrastructure development is also formulated in each of the ten regional blocks from Hokkaidō to Okinawa, based on the Priority Plan for Infrastructure Development corresponding with their regional plan based on the National Spatial Planning Act. Then, infrastructure can be developed efficiently and effectively based on each regional block's characteristics and will be consistent with the regional plan of the block. A regional priority plan for infrastructure development should include the current situation, major issues, future vision, infrastructure development strategy, prioritized goals, and planned projects within the block.

Regional priority plans for infrastructure development have the following three characteristics:

- Organization of major projects in a timeline
- Visualization of expected stock effects from the projects
- Classification of major projects as "effective use of existing facilities and promotion of soft measures," "thoroughly screened projects with large stock effects," and "integration and reorganization of existing facilities"

Priority Plan for Infrastructure Development

The Priority Plan for Infrastructure Development is not formulated unilaterally by the government like previous long-term plans but is formulated on the understanding that it is important to fully consider and reflect the needs of the people, the current situation in each region, and their requests regarding the direction of infrastructure development (e.g., public works reform) and the contents of priority objectives. To achieve this, more information is disclosed and more transparent procedures are established.

Its formulation starts with the Minister of Land, Infrastructure, Transportation, and Tourism consulting the Council of Infrastructure Development and Council of Transport Policy (simply called the councils) on reexamination of the Priority Plan for Infrastructure Development. The councils' membership is composed of experts.

First, the planning subcommittees of both councils discuss the first draft of the Priority Plan for Infrastructure Development developed by the Secretariat of the MLIT. Based on that discussion, a revised draft of the plan is formulated. Then, as stated in Clause 4, Article 4 of the Act on Priority Plan for Infrastructure Development, the revised draft is disclosed on the MLIT website for a certain period, and opinions from the people and prefectures are sought. Taking these opinions into account, the planning subcommittees of both councils discuss further. After additional discussions with related ministries, the final draft of the Priority Plan for Infrastructure Development is formulated. It is discussed and authorized by the planning subcommittees, related committees, and both councils as whole, and returned to the Minister of Land, Infrastructure, Transportation, and Tourism. The Minister puts it to the Cabinet and if the Cabinet concurs, it is authorized finally as a government plan.

Regional Priority Plans for Infrastructure Development

Regional priority plans for infrastructure development are formulated based on the national priority plan decided by the Cabinet.

First, each MLIT Regional Development Bureau collects opinions on infrastructure development from prefectures, designated cities, business communities, and experts. Then, each Secretariat of the Regional Development Bureau proceeds to make the draft of the regional priority plan according to the current regional situation, corresponding with the Regional Plan based on the National Spatial Planning Act and other regional priority plans. The Secretariat of the Regional Development Bureau discloses the draft on the Regional Development Bureau website for a certain period. As with the national priority plan, opinions or public comments from the people and municipalities are sought. Based on the opinions, the regional priority plan will be finally formulated and decided by the Minister of Land, Infrastructure, Transport, and Tourism and the Minister of Agriculture, Forestry, and Fisheries.

Decision Making for Projects

On decision making about public infrastructure projects' implementation, projects that are already prioritized in the Regional Priority Plan for Infrastructure Development, the Regional Plan, infrastructure development plan by project area, or comprehensive plan of local municipalities are given top priorities. Projects that are urgently needed by the society are also prioritized.

Procedures for decision making of national and regional projects are similar. As for national projects, the division of the Ministry in charge draws up the draft of the investment plan. (For regional projects, the division in charge in the municipality draws up the draft. In the two paragraphs below, which describe national projects, we will use parentheses to indicate the actors for regional projects.) The results of project evaluation by committees consisting of experts have been already combined into the investment plan. Next, information on the investment will be disclosed to the public in print and digital forms. Public comments, or opinions from the people, are sought. Public involvement (PI) at the planning stage has also become popular. The government often holds briefing sessions and workshops for stakeholders with great influence on project implementation to obtain their understanding and participation in the planning.

After the infrastructure investment plan is confirmed, the government goes on to acquire the budget. Adjustments with other investment plans and expenditure are first done within the division, then within the bureau (department), and finally within the ministry (municipality). The ministry (municipality) assembles its own budgetary requests (draft budget). Based on this budgetary request (draft budget), the division in charge works tenaciously to persuade the Ministry of Finance (department in charge of budgets) and ask for their understanding on the investment plan. The Ministry of Finance (department in charge of budgets) screens and assesses each budgetary request and organizes the final budget plan of the government (municipality). The budget for the investment plan is finally secured after deliberation and resolution by the Diet (local assembly). However, budget units for deliberation and resolution by the Diet (local assembly) are large, i.e., budgets are assigned in subsection and paragraph levels that only describe the objectives, functions, and direction of overall investments. Individual infrastructure projects are not always discussed.

After the resolution of the budget, the local branch office (department in charge), such as the MLIT Regional Development Bureau, creates a budget implementation plan. The budget will be implemented finally after the Ministry of Finance (department in charge of budgets) approves the implementation plan.

The budget for infrastructure projects will be finally implemented by local branch offices (department in charge). It is ideal to implement all projects as scheduled. However, considering urgent matters or political situations that arise, some projects are prioritized and implemented earlier with budget diversion from projects of the same type (it is permitted to divert budget for the same type of infrastructure projects within the same budget plan division without resolution of the Diet [local assembly]).

4.6.2 Decision Making by Financial Institutions and Investors

A lending financial institution's profit has an upper limit determined by the interest rate fixed by the contract. Therefore, financial institutions take careful precautions to avoid default risk of borrowers, that is, their loss due to uncollected loan funds. On the other hand, investors take large risks to pursue maximum profit.

4.6.2.1 Corporate Finance

Corporate finance is one of the methods for private companies to raise necessary capital. In corporate finance, financial institutions carefully examine the investment plan and judge the likelihood of repayment by investment profit to avoid borrower default risk. The financial institutions consider the companies' credit and take assets such as real estate as collateral to secure repayment in case profitability is lower than planned. Only then can they lend the companies the amount of money the collateral is worth. If the company cannot raise enough capital, they must consider acquiring funds from financial institutions with different funding policies or co-financing from multiple financial institutions, which is called a syndicated loan.

4.6.2.2 Project Finance

Infrastructure investment generally requires huge amounts of capital. Therefore, it is generally difficult for private companies to raise the necessary capital through corporate finance. Project finance, which relies on yet-to-be generated cashflow as a redemption source, must be considered.

Project finance without any backup assets as collateral is a high-risk financing method for financial institutions. Therefore, before considering project financing, financial institutions take a step to judge that the investment and its significance are worth considering the project finance. Then, financial institutions check the investment plan thoroughly and judge whether the capital can definitely be repaid from the investment.

The most essential point in evaluating an investment plan is the certainty of capital repayment. Therefore, it is necessary for the financial institution to confirm sufficient levels of not only indexes of profitability such as NPV and FIRR, but also debt service coverage ratio (DSCR), an index on ability of reimbursement. Furthermore, the robustness of profitability and certainty of capital repayment is also confirmed by sensitivity analysis. To supplement, DSCR is calculated as the cash flow of each year before paying principal and interest, divided by the repayment amount each year. In other words, DSCR shows how many times yearly cash flow is compared to the yearly repayments and shows the annual ability to repay. DSCR is expected to be over 1.2 in general.

Since the cash flow generated by the project is almost the only source of repayment for financial institutions, financial institutions sometimes require the implementing entity to hedge risks or try diversifying risks themselves by improving their financial scheme.

Some examples of such project measures that financial institutions require the implementing entity to take are to adopt proven technology, to make contracts to secure desirable risk sharing among experienced project-related entities, and to designate a back-up operator in case the operator goes bankrupt. One example of measures for the financial scheme that financial institutions themselves take is introducing a senior-subordinated structure in accordance with the risk preference of financial situations and investors. Senior loans are preferentially repaid from the repayment source, meaning they are low-risk and low-return, and subordinated loans are repaid after all the senior loans are repaid, meaning they are high-risk and high-return. Another example is risk diversification to invite multiple financial entities into a syndicated loan (it is especially preferred to include government-affiliated financial institutions in Japan).

After all the contracts regarding the investment are made, financial institutions conclude the loan agreement with the implementing entity, which is called the financial close.

Bibliography

Section 4.3

Boardman, A. E. et al. 2018. *Cost–Benefit Analysis: Concepts and Practice, 5th Ed*. Cambridge: Cambridge University Press.

Section 4.6

Study Group on Road Investment Evaluation, ed. 2000. Guidelines for the Evaluation of Road Investment Projects. Japan Research Institute.

Yescombe, E. R. 2013. *Principles of Project Finance, 2nd Ed*. Cambridge: Academic Press.

Chapter

5

Development of Infrastructure

I believe that… the world of technology holds out the greatest opportunity in all history….

— David E. Lilienthal (1899–1981), leader of the Tennessee Valley Authority.

5.1 Design of Infrastructure

5.1.1 Measurement and Survey

Measurements and surveys prior to construction are usually conducted by construction consultants or other professional corporations with facilities and proficient engineers. Here, we will look at examples about the information necessary for measurement and survey.

First, geography is the most important type of information in the construction of infrastructure. Topographic maps in both macro and micro scales are used to describe geography. A macro-scale topographic map, which is created based on aerial photography, uses the comparatively small scale of 1:10,000–1:25,000. Micro-scale topographic maps, created by geographical measurements on the ground, are prepared on a scale of 1:200–1:2,500. Geographical maps generally include the situation of land use, which is essential for designing infrastructure. Furthermore, in order to design facilities around rivers or seas, we need survey maps that contain the topographic information of riverbeds and sea floors/beds.

In addition to geography, geological conditions are also important. To identify the geological conditions, we conduct boring surveys prior to design. Then, we make geologic columns, which show the layers of the geological type by depth or maps with N-value, which represents the strength of the soils.

Other information is also essential, including meteorological conditions like wind speed and direction, temperature, and amounts of rainfall and snowfall. Also, there are hydrographic conditions like ocean currents and waves, and the amount of streamflow. Moreover, the vegetation or habitats of wild animals must be known for environmental impact assessment surveys. Engineers in charge of planning and design should know such environmental conditions.

Finally, as mentioned in Chapter 4, we should pay attention to historical remains. When conducting a project in an area with historical remains, we must investigate, record, and restore present conditions based on the Act on Protection of Cultural Properties.

5.1.2 Design of Infrastructure

Generally, the first step of manufacturing is designing, including deciding materials, forms, and power necessary to meet performance requirements. This can also be applied to the construction of infrastructure, but design is done before construction. The private sector entities rarely have their own design division because the investment in infrastructure is not regularly made. Thus, private sector entities outsource the design work to construction companies or construction consultants. Particularly in public projects it is typical to outsource it to design companies that are independent from construction companies in charge of construction, not a design team in a construction company itself. This is because infrastructure is usually owned and managed by the public sector and it should not be dependent on specific private construction companies in terms of social significance and public interest.

In principle, Japan has separated the tasks of design and construction in public projects by the official notice of the Vice-Minister of Construction in 1959. This means that design companies make drawings and specification documents, and then construction companies that win contracts through competitive bidding can construct the structures based on them. Design companies check whether construction companies comply with the drawing and specification, and if necessary, they change it and report the revised cost estimation to the implementing entities (construction supervision).

If one company or organization conducts both design and construction (i.e., design–build) and a project implementing entity has difficulty in supervising the task, construction consultants generally are engaged to supervise the overall task of design and construction on behalf of the project implementing entity (construction management).

Each piece of infrastructure has unique characteristics but there are also common aspects in their design. Here, we will look at those common aspects. In the design, we were given external conditions like the amount of water stream for river structures or traffic volume and geological condition for roads. “Design” is the work of deciding on design parameters that not only meet performance requirements but are the most economically efficient. To be more specific, design parameters are material, structure, size, and so on. We have two kinds of performance requirements to meet. One is the function that we expect infrastructure fulfills. For example, the function means that the river does not overflow even at high-water level or that roads have the necessary amount of traffic capacity for smooth traffic flow. The other performance requirement is that the structure is physically stable.

Satisfaction level against performance requirements can be obtained by calculation, using mathematical models based on the physical theories. After design parameters like materials, structure, or size are decided, based on those parameters we can estimate construction quantity, and cost of construction and maintenance. Design parameters defined to meet performance requirements are repeatedly modified in order to decrease costs as much as possible. An ideal set of parameters that meets performance requirements is to minimize the cost, but also meet performance requirements. We finalize the design documents to visualize design drawing and specifications including calculation data.

Performance requirements other than economical effectiveness like the effect on the landscape are considered as well. In that case, we include it as one of the performance requirements beforehand. Thus, we can generally consider and try several sets of design parameters and compare them, and then select the most economical one as the best design.

Next, we will look at the external conditions. It is difficult to forecast future external conditions because they depend on the natural environment. Also, the accuracy of the mathematical model, which is used to speculate on the effect of future external conditions on facilities, is not necessarily high. Thus, we speculate on external conditions with a safety ratio and secure as much safety as possible. For example, when considering flood flow, we can speculate that it will be 110% of the maximum flood flow forecast by the mathematical model or that physical stability of the facility is estimated setting the one-third level of fracture stress as an allowable value.

We use computer-aided design (CAD), which is software to help us to carry out the design work such as model calculations, design drawings, and cost estimates. It enables us to design more efficiently and to improve design quality because it calculates and visualizes quickly, and we can try various scenarios in less time. Also, construction information modelling (CIM), which is more sophisticated software than CAD, has recently been developed. CAD displays design two-dimensionally, but CIM displays it three-dimensionally, which can decrease design errors, e.g., check interference between the respective components, and enable more precise estimation. We can also visualize the results of other analyses like earthquakes or flood flow simulation. In addition to its contribution to design, it is also expected to be used in all stages from design and construction to maintenance.

Errors in the design may cause serious accidents or disasters in the later stages such as construction or operation. Thus, if those responsible overlook such errors, they can be called to account in civil or criminal law. Those responsible for design should seriously recognize their social responsibility. In the unlikely event that negligence or errors happen and result in defect professional liability, there is liability insurance for construction consultants as a system.

5.2 Environmental Assessment

5.2.1 System

Construction and management of infrastructure inevitably has some effect on the environment. Though infrastructure projects are planned and developed to improve social welfare, they can generate adverse effects if they damage the environment. Recovery will take a great deal of time and money, and complete restoration may be impossible.

Thus, we are required before project implementation to conduct surveys for assessing and forecasting environmental impacts, and we must take necessary measures against those potential impacts. Further, the results and evaluation of surveys should be disclosed to the public, and residents' opinions should be reflected in the project contents.

In Japan, the Basic Environment Act was enacted in 1993 and indicated the basic principle that we should decrease environmental impacts as much as possible and build up a sustainable society for future generations. Then, in 1999 the Environmental Impact Assessment Law was finally enacted. Project implementing entities are obliged to follow the procedures based on this law and assess environmental impacts. Then, permission and authorization are given to projects according to the assessment results.

5.2.2 Target Projects

Target projects for environmental impact assessment are ones undertaken by the public sector and ones with approval or subsidy, and from which huge influences on the environment are expected. This covers almost all infrastructure such as roads, railways, rivers, and land readjustment projects. Projects are divided into two classes: Class-1 and Class-2. Class-2 projects are comparatively small-scale like constructing a 2-lane-road shorter than 7.5 kilometers (other roads are classified as Class-1). In Class-2 projects, a screening process decides whether an environmental impact assessment is needed. In Class-1 projects, an environmental impact assessment always must be done.

5.2.3 Procedure of Environmental Impact Assessment

Project implementing entities must prepare documents for every step of the procedure of the environmental impact assessment. After the following documents are approved, they can proceed to the implementation stage of the project.

- Documents on primary environmental impact consideration: reviewing items that should be considered for environmental conservation
- Scoping documents: showing evaluation items and how to evaluate them
- Draft Environmental Impact Statement: disclosing assessment results
- Environmental Impact Statement: finalizing report modified with opinions through the disclosure of assessment results

For each of these steps, planners seek the opinions of stakeholders including residents, governors, city managers, and the primarily responsible ministers like the Minister of Land, Infrastructure, and Transport and the Minister of Environment. If necessary, the documents are modified based on this input.

5.2.4 Basic Items of Survey, Forecast, and Evaluation

The Ministry of the Environment designates the basic items for the entire survey, forecast, and evaluation of the environmental impact assessment as follows: target environmental item (air, quality of water, soil), project range (construction, existence, and activity), and workflows of survey, forecast, and evaluation.

5.3 Land Acquisition

Land is always necessary in order to construct infrastructure. Thus, land acquisition is the most fundamental work in the project and all those concerned should have basic knowledge about it. To that end, in this section, first we describe the fundamental knowledge related to land. Then, we look at problems of land acquisition.

5.3.1 Characteristics and Registration of Land

Land is a good and can be traded. But land has characteristics that other goods do not: it can be divided or combined, and its borders depend on our recognition. Thus, it is necessary to specify borders of land by cadastral surveys and protect the property rights of land owners by registration.

In a cadastral survey, we number each land lot, measure the position and its range, and specify it on a map (the Article 14 map, which is provided in Article 14 of the Real Estate Registration Act in Japan). Each land lot is shown on the map and identified using coordinates. In Japan, cadastral surveys still have not covered all the land, and there are still some plots of land whose cadastral data have not been obtained. In that case, the land registry map can be used, but we have to keep in mind that it is not necessarily accurate.

Each piece of land is registered in land registration documents with the name of the land owner, number, category, and area, so that the property rights of the land owner can be protected. The property rights of land permit exclusive ownership of the land, which means that land owners have the right to freely use, profit from, and dispose of land, so land owners must be publicly identified. If land is purchased or sold, the transfer should be registered. If a mortgage is established on the land, the settlement of the mortgage should be registered as well.

5.3.2 Property Rights and Their Regulation

Land is a limited resource, and its use has social and economic effects on the surrounding area due to externalities. Thus, land property rights are regulated in terms of public interest based on the basic principle of the Constitution and Basic Land Act. Such regulations are based on public laws, such as the Land Acquisition Act, City Planning Act, Agricultural Land Law, River Act, and Building Standard Act. Civil law defines land property rights as covering the range from the air above the land to the ground below it. But the Act on Special Measures Concerning Public Use of Deep Underground states that there is no need for permission or compensation for public use deeper than 40 meters underground. This act enables the establishment of facilities like underground railways without any permission or compensation if they are planned to be built deeper than the depth of any basements or building foundations.

5.3.3 Superficies

Superficies are the right to use the lands of other land owners in order to own works such as roads on the land. Superficies are established by contract or will. Those who have superficies can use land within limited specific purposes.

When superficies are set in the limited range of the underground or air above, this is called the sectional surface right. Superficies for underground railways are set within the underground space and superficies for bridges are set within the space above the ground. But the sectional surface right is not set for construction projects for public purposes under 40 meters deep, as mentioned previously.

5.3.4 Land Purchase

Generally, land purchase is to gain land for the construction of infrastructure. Voluntary land purchase is where project implementing entities gain the land property rights by paying compensation based on a contract through a bilateral agreement between the project implementing entity and land owners. Land price as compensation is based on the market value and it is to be calculated by road rating based the land value assessment method. This assessment method is decided by roadside land price, depth of the lands, and elevation difference, which is set by the National Tax Agency. Also, the compensation price may include the amount that land owners will need in order to build the same building on new land, which is replacement compensation.

5.3.5 Land Expropriation

In principle, land purchase is based on voluntary acquisition, but there are some cases where it is not possible to reach an agreement with land owners. For construction of roads or railways, the project implementing entity cannot complete the project with even one land owner unwilling to sell land, and this can cause large losses on the part of public interest.

Thus, the Constitution of Japan states that private property can be used for public use with fair compensation. Based on this, the Expropriation of Land Act states that the government or a local public organization can acquire private property such as land after conducting necessary procedures even if land owners are against it. The Expropriation of Land Act also clarifies the necessary requirements, procedures, effects, and compensation for the loss. Project implementing entities can expropriate private lands only for projects to which the Road Act, the Railway Business Act, the River Act, the Water Supply Act and so on are applied.

The project implementing entity must go through the following procedures in order to prove the necessity of expropriating the lands. First, project implementing entities must hold a briefing and explain the project contents to the stakeholders, and then gain approval from the Minister of Land, Infrastructure, Transport, and Tourism or the governor. After gaining approval, project implementing entities must apply to the expropriation committee in the prefecture for the adjudication on land expropriation. Land expropriation committees start their proceedings after a certain period of project contents disclosure. If the committees decide to approve it, the committees also need to clarify the area of the lands that will be expropriated, the amount of compensation for the loss, and the terms of the expropriation. If land owners have complaints with their decision, they can appeal to the Minister of Land, Infrastructure, Transport, and Tourism for more investigation.

As mentioned in the paragraphs above, the procedures of land acquisition for public purposes are defined by law. But it takes a long time for the land acquisition committees to make their final decision, so the Act on Special Measures Concerning Acquisition of Lands for Public Use also states that emergency adjudication is possible if a project delay is expected to cause huge damage to the public interest. This emergency adjudication system was used in the construction of the New Tokyo International Airport (currently called Narita International Airport).

5.3.6 Land Reallocation

Land readjustment projects improve the utilization of building lots by changing the zoning, shape, and quality of lands and creating public facilities such as roads and parks. A certain portion of land is provided from each building lot for the projects, and in this way the project implementing entities can secure the necessary land. This is based on the idea that land value will increase after public facilities are established by the project, so land owners should offer land in an amount equal in value to the increased value for public use.

Land offered for public purposes is called land decrease. The proportion of the offered land to the original land is called the ratio of land decrease.

There are two types of land reallocation according to the use of the land: one is land for public spaces in order to establish public facilities like roads or parks; the other is reserved land in order to obtain investment capital by selling it.

In agricultural land, the project implementing entities rearrange land lots aiming to improve the efficiency of agricultural productivity and to establish agricultural roads or waterways, by land reallocation based on the Land Improvement Act.

Road projects often involve land reallocation. Especially, many redevelopment projects in urban areas acquire land for roads by integrating the surrounding areas.

5.3.7 Public Land and Underground Malls

Land for facilities that an unspecified large number of people use, like roads, plazas, parks, and rivers, is called public land. Public land is managed by national and local governments. This public land can often be dually used to establish infrastructure for different purposes from the original. One example of such a case is establishing telegraph poles, underground pipes, and shopping malls under road lots. These facilities are treated only as occupied property, not sectional property, so charges for occupation are paid to land owners. In the underground malls, a basic rule is that the area of aisles is larger than that of shops. Aisles are seen as public space and managed by road managers, and only shops are considered as occupied property.

5.3.8 Landfills and Land Reclamation

Land is a limited resource but there are two methods to increase it: landfill of water surfaces and land reclamation. A landfill is a way to dispose of dredged soil, construction waste soil, and waste in a shallow bay or lake. Land reclamation is used to close off a shallow part of a sea or lake and then drain the water. Land increased by landfills covers 0.5% of Japan. But both landfill and land reclamation have large influences on the natural environment and can cause ecological destruction. Thus, the Act on Reclamation of Publicly-Owned Water Surfaces has strictly regulated land acquisition from public water surfaces like rivers, lakes, and seashores, requiring permission from the governor. Projects involving landfills and land reclamation must obey the Environmental Impact Assessment Act, and permission and authorization from this viewpoint is also necessary.

5.4 Construction Contracts

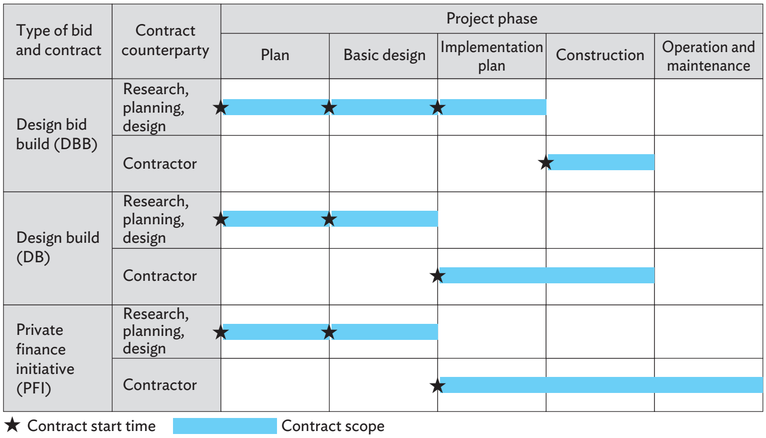
5.4.1 Necessity and Significance of Contracts

Every piece of infrastructure is unique, and it needs substantial investment and cooperation from many entities concerned for a long time. Thus, the implementing entities generally lack the ability to build up the whole infrastructure by themselves only. Therefore, they need to order contractors who can construct part or all of the infrastructure to do it. As for infrastructure, it is unforeseeable whether contractors can construct infrastructure that satisfies the required quality (performance requirements), without any delay and within budget because these points depend on the technical ability of contractors. Thus, project implementing entities must clarify the detailed requirements of the infrastructure and confirm that the contractor can responsibly promise to construct infrastructure with those requirements.

Moreover, bilateral and legally binding agreements must be made about what measures contractors and project implementing entities will take in the event that the requirements are not fulfilled, such as compensation or cancellation of contracts. This is to prevent unnecessary conflicts and save time, money, and effort. It is necessary to agree in advance how much and how they will pay if the requirements are fulfilled. Such agreements for a large project are complex, involving multiple contractors, and the implementing agency needs to take up additional responsibilities to execute the project smoothly within the approved budget and time.

In Japan, there are many contractors that can achieve the requirements of high-quality infrastructure. Thus, the most suitable contractors need to be selected by competition. There are some cases where only one contractor can meet the requirements because the

Figure 5.1: Type of Bid and Contract and their Scope



Source: Authors.

project requires special skills. In that case, the criteria and process of decision making need to be explicitly stated for the sake of transparency. Methods and procedures to choose contractors are called the bidding and contract system.

5.4.2 Target Range of Contracts and Timing for Making Contracts

The process of construction projects has 5 steps: 1) plan, 2) basic design, 3) implementation plan, 4) construction, 5) maintenance. There are three types of bidding and contract systems, and we will examine their differences in the next paragraph. Figure 5.1 shows the overview.

Currently, most general bidding and contract type in Japan is a design-bid-build (DBB) method. In this method, the implementing entities are responsible for stages 1 to 3. Construction companies are only responsible for stage 4 (construction). In the design–build (DB) method, construction companies are also involved in stage 3 (implementation plan) as well as stage 4 (construction). The last method is private finance initiatives (PFIs). In both DB and PFI, the implementing entities are responsible for stages 1–2, but not for the implementation plan. The biggest difference between the DBB method and the other two methods—DB and PFI—is whether the implementing entities are involved in the implementation plan. Thus, whether to outsource the implementation plan and construction separately should be decided at stage 1 (plan) or 2 (basic design). In Japan, it is stated by the guideline on application of bidding and contract type in public works (the Ministry of Land, Infrastructure, Transport and Tourism) that the bidding and contract system are basically selected before the preliminary design and reexamined at stage of design and during the ordering procedure of construction.

5.4.3 Main Contents of Contracts

5.4.3.1 Specification of Target Infrastructure

The contract states the specifications with constraints and consideration of what infrastructure will be made. The detailed specification including drawings, measurement, material, and method of construction will be attached to the contract paper as the drawing and specification. There are two ways to define the specification according to the subject. One way is that the project implementing entities define it with support from a design consultant. The other is that the implementing entities provide the performance requirements of the target infrastructure, and then candidates of contractors propose them as part of their bidding documents. When the most suitable contractor is selected, their proposal is used to finalize the specification.

5.4.3.2 Constraints and Consideration Items

The constraints and methods of construction are specified in the contract. It describes the required quality (performance requirements), restrictions like budget or construction period, safety of the construction site and effects on the environment, and effect on the surrounding traffic. As mentioned in the previous section, the implementing entities may specify the requirements in detail beforehand, or only the minimum requirements to be satisfied in the bidder's proposal. In the latter case, the most suitable proposal will be chosen, and the constraints are specified based on it.

5.4.3.3 Payment

The contract will also specify the amount, timing, and method of payment that the project implementing entities will pay to the contractors when complete or proceed the project based on the contract. Table 5.1 shows methods to decide the amount of payment such as lump-sum contract, lump-sum contract and unit price agreement, cost reimbursement contract, and cost-plus-fee contract. The implementing entity selects one of those methods, considering the risk of volatility of construction costs, incentives for contractors, and so on.

Table 5.1: Type of Contract by Method of Deciding Payment Amount

Type of Contract	Contents
Lump-Sum Contract	• Reimbursement amount is fixed in the contract • Generally, the amount is not changed after contract conclusion
Lump-Sum Contract and Unit Price Agreement Procedure	• Reimbursement amount is fixed in the contract • Negotiate and make agreement on unit price in advance in case of change of reimbursement amount • The aim is to facilitate negotiation of design change or partial payment
Unit Price Contract	• Make agreement on unit price of each work package based on anticipated quantity in advance • Reimbursement amount is fixed with quantities required to carry out each work package
Cost Reimbursement Contract	• Reimbursement amount is fixed as actual final project cost • In most cases, all the items are not subject to this contract but limited to the direct cost, and indirect cost is fixed in advance
Cost Plus Fee Contract	• Reimbursement amount is fixed as actual final project cost plus fee • The fee can be fixed amount, fixed rate, incentive, and the like

Source: Authors.

Table 5.2 shows payment methods such as lump-sum payment, advance payment, and progress payment. Project implementing entities select one of these methods, considering the risk of construction cost fluctuation and incentives for construction companies.

Table 5.2: Type of Contract by Payment Method

Type of Contract	Contents
Lump-Sum Payment	• Pay the entire payment to the contractor immediately after project completion
Advance Payment	• Pay partially (e.g., 40%) immediately after contract conclusion as advance payment and pay the rest immediately after project completion • Payment type with consideration of the contractor's cash management
Progress Payment	• Pay regularly according to the amount of work completed • Payment type with consideration of the contractor's cash management. Delay risk reduction is expected due to the incentive to shorten the project duration

Source: Ministry of Land, Infrastructure, Transportation, and Tourism. 2010. *Implementation Manual for Progressive Payment*. Tokyo.

5.4.3.4 Risk Management

Construction projects involve unexpected events, so the implementing entity and the contractor specify measures to decrease unexpected damage in the contract in advance. The construction companies submit what we call a performance bond. It is a document that ensures a monetary guarantee and service guarantee in the case that construction companies fail to fulfill the contract. The monetary guarantee is compensation for the project implementing entities, and the service guarantee is entrusting another company to take over the responsibility of completing the construction if the original construction companies could not. Two parts address unexpected damage: one specifies the procedures to reduce the possibility of unexpected damage and the other specifies the necessary procedures if damage occurs. Concretely speaking, contracts specify monitoring and supervision by the project implementing entities to prevent the risk of construction companies not properly executing the contract.

Contracts specify the procedures of compensation or cancellation of contract and decide whether the damage is attributed to the project implementing entities or construction companies. But if it cannot be attributed to either implementing entities or contractors—what we call force majeure—like war, terrorism, riots, strikes, or natural disasters, contracts generally specify that the project implementing entities would have to take responsibility because they are expected to have more ability than construction companies to endure such unexpected damage.

5.4.3.5 Subcontract

In Japan there are what we call super-general construction companies. They are the prime construction companies for large-scale projects in various professional fields.

For the construction of infrastructure in Japan, super-general construction companies usually divide the overall construction task into various tasks and make contracts with subcontractors for each divided task. In some cases, those subcontractors divide the task into finer tasks and distribute them to second subcontractors. The contract specifies the requirements of the subcontract so that the original requirements are met even if there are multiple layers between the super-general construction companies and the lower ones.

5.4.3.6 Parties of Contracts

The parties of contracts are those who represent the organization and take legal responsibility for the conclusion and fulfillment of contracts. The Financial Act and the Local Government Act state that parties from the public sector side of contracts will be the minister for the national government and the governor for local governments, respectively. In the public sector, a portion of the tasks can be assigned to an officer responsible for authorizing expenditures. Also, if the project implementing entity is the government, they can divide the work into more small-scale tasks and assign them again to other officials responsible for authorizing expenditures. However, the minister or governor has the final responsibility of the contract. In the private sector, the individual with representative rights is responsible for the contract. As in the public sector, their work can be assigned to subordinates based on the organizational rules according to the range and significance of the contract and construction area. However, the company representative has the final responsibility.

5.4.3.7 Standardization of Contracts

It is inefficient to make each contract from scratch and build consensus because it takes a huge amount of time and money. Thus, there are standardized packages for every kind of construction contract (public construction, private construction, and subcontracting). Overseas construction projects are based on the International Federation of Consulting Engineers contract, which is widely used as a de facto standard of contracts for international construction projects and by international financial organizations such as the Asian Development Bank, the Japan International Cooperation Agency, and the World Bank.

5.4.4 Bid and Contract Method

5.4.4.1 Principle

The principle of infrastructure construction is to select the construction company that provides the most advantageous conditions and can fulfill the contract. The most advantageous conditions depend on the project implementing entity's intentions. Every contract has three factors. First is constraints (budget, construction period, and quality), second is considerations (ensuring safety on-site, effects on the surrounding environment and transportation), and third is others (revitalization of the local economy, promotion of local employment, securement of future workers). The bidding and contract method or conditions balances these three factors so that the project implementing entities can achieve their purpose.

If the project implementing entity is a public organization, general competition has to be adopted based on the Public Accounting Law, and the selection process must provide fair chances and transparency to obtain understanding from stakeholders. If it is a private organization, the implementing entity need not introduce general competition and can directly request specific private companies, such as its own affiliated companies. Stockholders' intentions are the main factor in that case.

5.4.4.2 Technical Requirements

Implementing entities must state technical requirements such as constraints and considerations in the specification and drawing so that the contractors can consider whether they participate in the bidding. There are two ways to specify technical requirements: performance specification and prescriptive specification.

Performance Specifications

Performance specifications indicate the performance requirements of the infrastructure as technical requirements. For the detailed design contracts, Design–Build (DB), or PFI methods, it is difficult to specify detailed specifications because the order is placed before the detailed design stage. Thus, the project implementing entity specifies only performance requirements, not detailed specifications, and requires applicants to propose plans that meet those performance requirements.

However, there are also cases to specify detailed specifications before the detailed design stage rather than performance requirements. Specifications are often standardized so that performance needs to be strictly fulfilled, especially for measures on factors like safety or the environment. Therefore, standardized specifications are often used as technical prescriptive requirements. Even when the specifications are not standardized, project implementing entities might specify detailed specifications that meet the performance requirements.

On the other hand, there are cases in which performance specification is used even when prescriptive specification is possible. For example, in competitive bidding, public implementing entities must specify standardized construction methods in prescriptive specifications available to contractors to secure transparency and fair selection. However, they can receive proposals and adopt special construction methods when they specify performance specifications instead of prescriptive specifications. This can occur in cases that are intended to overcome special constraints like cost reduction, earlier construction completion, environmental impact reduction, completion risk reduction, and so on.

Prescriptive Specification

Prescriptive specifications indicate details such as construction methods, material, shape, and size as technical requirements. The construction contract is made after the detailed design, so the project implementing entities can designate prescriptive specifications with help from construction consultants if needed.

As mentioned in Section 5.1, there are various options for specifications that meet the performance requirements (materials, shape, size, construction method, and various combinations thereof). It can be said that project implementing entities designate the best prescriptive specifications as technical requirements among all the possibilities that meet the technical requirements.

5.4.4.3 Participants in Bidding and Contracts

There are several methods to select participants in the bidding and contracts process, such as general competition, selective bidding, and discretionary contracts. In general competition, any organization can participate if it meets the qualifications. Thus, the system needs to be designed to not select construction companies unsuitable to the project. In selective bidding, only appointed participants may participate in the competition. In discretionary contracts, the project implementing entities make contracts with specific companies. Discretionary contracts can be applied to the special cases like when one company holds a needed patent. In cases in which a project implementing entity appoints contractors without price competition, such as a public offering proposal competition, such contract type is also a discretionary contract. If many applicants participate in a competition where the project implementing entities require submission of technical proposals, the bidding and contract process may become inefficient because of a mutual burden on both the implementing entities and applicants. Thus, it is important to set qualifications such as applicants' financial condition, past performance, or legal compliance in order to proceed efficiently with the bidding and contract process, avoiding selection of unsuitable candidates.

If it is objectively clear that only a limited number of companies can meet the qualifications and technical requirements, the selective bidding method is reasonable. Furthermore, it is clear if only one company is available, a discretionary contract is of course reasonable.

There are some cases in which multiple corporations cooperate and make one organization, which we call a joint venture, as a counterparty of one common contract. The merit of this method is that the project risk can be divided, and member companies can supplement each other with the advantages of different professional fields for the implementation of the project. However, this method can also be applied to corporations in the same field, not different fields, to share work.

5.4.4.4 Bidding and Contract Methods

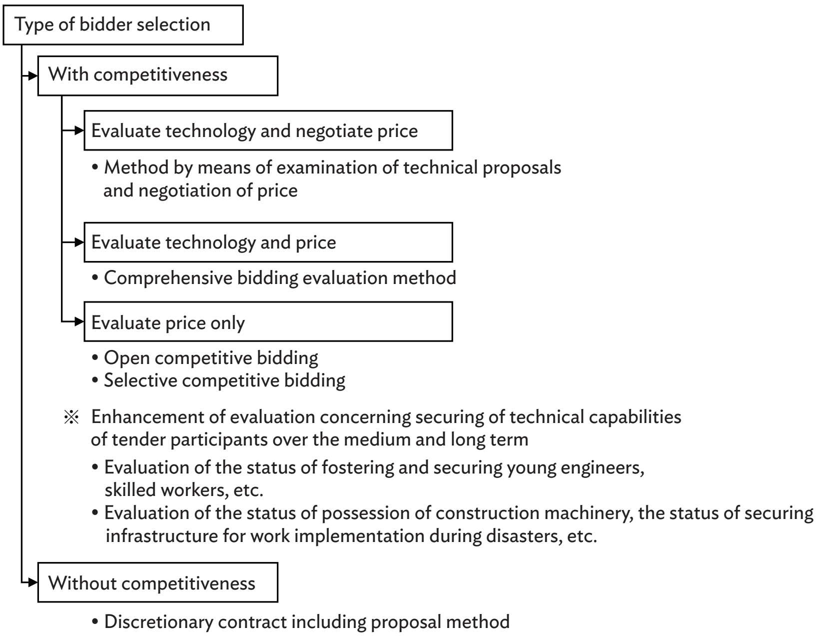
The Public Accounting Act and Local Autonomy Act state that those offering the lowest price shall essentially be selected as the counterparty to a contract, which is called the lowest price bidding method. But as mentioned, since the quality of infrastructure depends on the technical ability of construction companies, it is not reasonable to select construction companies that merely offer the most economically advantageous plan based on the price of construction.

Thus, the Act on Promoting Quality Assurance in Public Works has been enacted. This act has introduced the comprehensive evaluation bidding method, in which project implementing entities can consider various technical factors other than the price in selecting construction companies. The act has been revised after its initial enforcement and it now puts more emphasis on technical factors. The revised act also has four additional advantages. First, it has introduced a step-by-step method for the selection of construction companies in order to decrease the burden. Second, it has introduced methods that directly reflect the intentions of the project implementing entities, which contribute to the assurance of project quality and development of human resources in the medium and long term. Third, it has introduced the retention of region type contract method, which contributes to the operation and maintenance of social capital by multi-year contracts and comprehensive commission. This method enables small and medium-sized companies that have valuable knowledge about each community to regularly get orders. Fourth, the revised act has encouraged the appointment of young or women engineers. Figure 5.2 describes various bid and contract types.

5.4.5 Support for Project Implementing Entities

In some methods, if the project implementing entities do not have enough manpower or ability, other organizations can support the project implementing entities by doing part of the tasks so that the project implementing entities can fulfill their responsibility. The construction management method (CM method) and project promotion public–private partnerships (PPPs) method are examples of support for the project implementing entity. The CM method is to get private consultant companies to replace part or all of the project implementing entities' work as construction managers, on behalf of the project implementing entities, in each stage from design to construction. The project promotion PPP method is to get a group of private engineers to work together with the project implementing entity on the implementation process before construction.

Figure 5.2: Various Bid and Contract Types (Type of Bidder Selection)



Source: Ministry of Land, Infrastructure, Transport and Tourism. *The Problems on the Bid and Contract System and Future Directions of System Amendment to Solve the Problems* (draft).

5.4.6 Private Finance Initiative Method

Recently, the PFI method, which has enabled the establishment of necessary public facilities through the investment of private companies, has been used because the financial stringency of the public sector continues and this method can decrease their expenditure.

Table 5.3 shows the characteristics of PFI. General public projects share the same elements of the bidding and contract system with the PFI method in that they can introduce performance specifications, general competition, and the comprehensive evaluation bidding method. However, when the PFI method is taken, the project is required to combine these elements properly and include the stage of financing, operation, and maintenance in the scope, which makes the PFI method different from the bidding contract system of conventional public projects.

In Japan, the PFI method was mainly used to establish public facilities until 2011. Since the concession method was introduced by the amendment of the PFI Act in 2011, private companies can have wider rights and get to participate in the operation of public infrastructure,

Table 5.3: Characteristics of Private Finance Initiatives

Item	Contents
Scope	Consistent process after planning: design, construction, operation, and maintenance
Technical Requirements	Performance specification in general
Bidders	Open tender
Selection Type	Comprehensive bidding evaluation method, open call for proposal method → Method by means of examination of technical proposals and negotiation of price
Payment	No payment for infrastructure development. Investment recovery through operation to provide service • Financially free-standing type: Investment recovery through fee revenue from users only • Joint venture type: Investment recovery through fee revenue from users and subsidy if investment recovery is difficult with fee revenue alone • Services sold to the public sector type: Investment recovery through revenues paid by public sector client for service provision

Source: Authors.

which has enabled them to collect tolls on existing public infrastructure such as airports. Now private companies' investment and management know-how are being incorporated into public projects through the PFI method.

The PPP/PFI Promotion Action Plan (revised in May 2016) has encouraged the PFI and PPP methods where public organizations can cooperate with private companies in order to supply public services. Specifically, the PPP/PFI Promotion Action Plan aims to implement projects worth ¥21 trillion (roughly $200 billion at the time of this writing) in total between 2013 and 2022. The targets of the action plan are public projects conducted by ministries such as the Ministry of Land, Infrastructure, Transport, and Tourism, and all municipalities with populations larger than 200,000.

5.5 Construction

5.5.1 Overview

This section discusses responsibilities of both project implementing entities and contractors. Project implementing entities are responsible for managing and monitoring so that infrastructure is appropriately established. They check negligence or errors by contractors, encourage cooperation among the contractors concerned, and manage the whole infrastructure project. Contractors have the responsibility to fulfill the contract with the project implementing entity under their management and monitoring. The comprehensive technical system to make sure that every stakeholder carries out their responsibility is called project management.

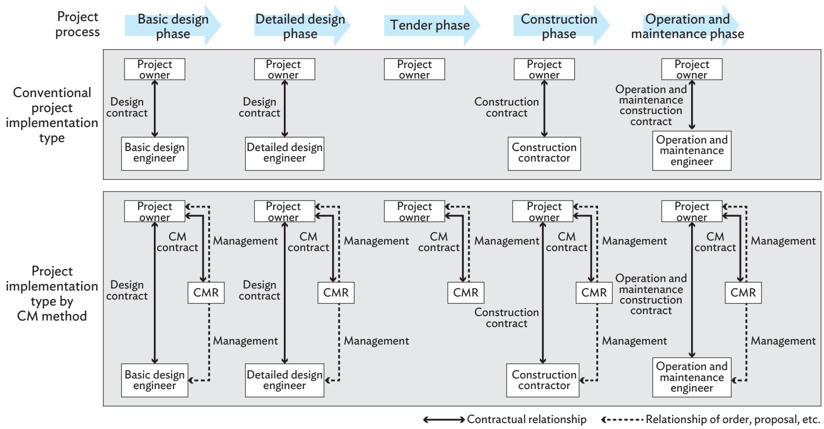
5.5.2 Responsibility of Project Implementing Entities

Project implementing entities must manage and monitor contractors in order to check whether there are errors or negligence, and they must secure enough workers and ability so that they can check thoroughly. If the project implementing entities lack workers or abilities, the construction management method must be applied to replace a part or all of their work by private consultant companies. Project implementing entities should check the implementation progress even in the middle of the construction stage and each time take appropriate measures if necessary. To prevent future risks, it is also important to identify prior signs.

If troubles occur, contractors should discuss closely with the implementing entities how to resolve them. If the trouble causes damages to a third party, the project implementing entity must compensate for the loss. If the project implementer is a public organization, the government must compensate for the loss based on the State Redress Act. If the damage was caused by the construction companies concerned, the project implementing entity could ask them for compensation.

What is considered as damage to a third party or considerations to the surrounding environment has varied over time. For example, there were some construction projects such as the development of tunnels or dams that involved the loss of workers' lives for some time after World War II. Also, impacts on the environment like air pollution, water pollution, decline of the ground water level, and dust generation had not been considered enough at that time. But afterwards or recently, awareness of adverse effects on the surrounding environment has been growing. Now we must consider not only safety measures on construction sites and pollution prevention, but also other effects such as environmental conservation and the impact on surrounding traffic and landscape. Project implementing entities include those aspects as the requirements in the bidding documents and contract, and after construction of infrastructure is completed, they must check whether all requirements in the contract are satisfied. Figure 5.3 shows the relationships among the various entities depending on the construction method.

Figure 5.3: Project Implementation Type by CM Method (Pure CM)



CM = construction management.

Source: Japan Civil Engineering Consultants Association. 2012. *Guidelines on Practical Use of Construction Management System*. Tokyo.

5.5.3 Responsibility of Contractors

Contractors must fulfill the contract by full use of their technology, knowledge, and abilities. Currently, contractors have higher technical knowledge and more information than project implementing entities. In other words, there is asymmetry of information in the field between project implementing entities and contractors. Thus, contractors must report the current project progress and its outlook, concerns such as potential risks and its signs, and occurrences of accident and disaster properly to project implementing entities. In particular, if contractors find warning signs of potential risks, they must have close contact with the project implementing entity and quickly take prevention measures before it occurs. If risk occurs, they must also have close contact with the project implementing entities, discuss the countermeasures with them based on the contract, but flexibly, and take appropriate countermeasures promptly.

Bibliography

Hughes, W., R. Champion, and J. Murdoch. 2015. *Construction Contracts: Law and Management, 5th ed.* New York: Routledge.

Chapter

6

Operation and Maintenance of Infrastructure

A natural disaster will hit us at around the time when we forget about the last one.

— Torahiko Terada (1878–1935),
Japanese geophysicist and author.

6.1 Maintenance of Infrastructure

6.1.1 Meaning of Infrastructure Maintenance

The raison d'être of infrastructure is to provide a long-term service to the people. For example, the useful life of a paved road designated by law is around 10–15 years, but the actual life of the infrastructure is longer, in some cases over 100 years. Forth Bridge in the United Kingdom (UK) is famous for its long useful life. The bridge's construction was completed in 1890 but is in operation as a railroad bridge even now. The Tōkaidō railroad line in Japan, which connects Tokyo and Kōbe, is still one of the most important trunk lines although it started its operation in 1889.

In this way, the useful life of infrastructure is very long, but it becomes depleted physically year by year and its function becomes outdated. Therefore, it is necessary to continue regular inspection and maintenance. This requires large-scale reconstruction in some cases for providing enough services meeting the needs of the times.

Dysfunction of infrastructure arising from insufficient maintenance causes great loss to the community and sometimes can lead to serious accidents. Therefore, it is crucial for infrastructure projects to continue suitable maintenance to prevent dysfunction or accidents.

Of course, the target or the approach of maintenance differs among infrastructure projects. The operator of infrastructure establishes suitable regulations and carries out operation and maintenance according to the regulations. We will describe some ideas and methods of infrastructure maintenance with reference to examples.

6.1.2 Current Status and Issues of Infrastructure Maintenance

Maintenance of infrastructure has recently been in the spotlight in Japan. A government report on road facility management in 2003 mentioned the term "asset management." The Japan Society of Civil Engineers in 2005 published a book, *Challenge for Introducing Asset Management*. Since many years have passed following the intensive construction of infrastructure facilities after the period of high economic growth in Japan, two serious issues have arisen: aging of infrastructure and lack of inspection of infrastructure.

In December 2012, the ceiling boards for ventilation fell at Sasago Tunnel in Chūō Expressway. Nine people were killed and two people were injured in this accident. The investigation committee in the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) pointed out that the causes of the accident were poor examination and maintenance as well as insufficient strength of the bolts connecting the steel ceiling boards with the ceiling. Media reports including TV stations and newspapers reported the accident, and infrastructure maintenance gained a great deal of attention.

The accident at Sasago Tunnel occurred under the management of a large-scale company, Central Nippon Expressway Company Limited, but infrastructure maintenance by local governments including prefectures or municipalities is even more serious. Many infrastructure facilities are under the management of prefectures and municipalities, and the average age of these facilities exceeds 30 years. Many municipalities are not able to inspect their facilities due to the shortage of human resources and budget.

The issue of infrastructure maintenance became serious in the United States (US) 30 years earlier than in Japan. Much of the American infrastructure was developed after the New Deal Policy in the 1920s. On the other hand, Japan's major infrastructure development occurred in the 1960s to the 1970s. As a result, many road facilities in the US deteriorated in the 1980s. In 1981, Pat Choate and Susan Walter warned of the deterioration of infrastructure in their book, *America in Ruins: The Decaying Infrastructure*.

The US government made a long-term plan of infrastructure maintenance and replacement. The government enlarged the financial resources for this by increasing the gasoline tax and allocating it to infrastructure maintenance and replacement.

The American Society of Civil Engineers also evaluated the current status of infrastructure including bridges, roads, railways, water and sewage, energy, dams, ports, and airports and estimated maintenance and replacement costs (Table 6.1). In the report, a lot of infrastructure was evaluated as fourth (D, or "risky") out of five grades, and promoted national understanding of the need for infrastructure maintenance and replacement. The American Society of Civil Engineers also estimated the investment cost for keeping infrastructure level as the second (B, or "good") out of five grades. The cost has increased year by year, and it was estimated in 2013 that the total cost until 2020 was \$3.6 trillion; \$1.6 trillion short due to lack of financial resources. This shows the importance of infrastructure maintenance and the scale of maintenance cost to the people of the US.

In Japan, MLIT estimated the maintenance and replacement cost of infrastructure including roads, ports, airports, public rental housing, sewage, city parks, rivers, and coastal management facilities in a white paper (Figure 6.1). It states that the required cost between 2011 and 2060 is about \$1.9 trillion, about \$300 billion short. This trial calculation offers a reference for infrastructure maintenance and replacement in Japan.

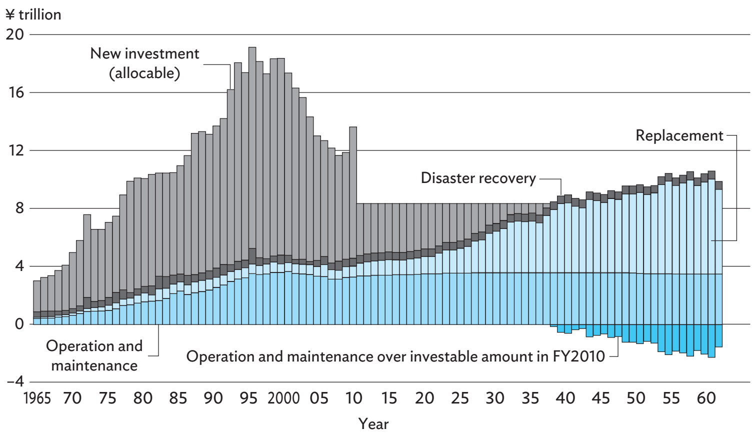
Table 6.1: Current Status of Infrastructure in the United States Evaluated by the American Society of Civil Engineers

Category	1988	1998	2001	2005	2009	2013
Aviation	B–	C–	D	D+	D	D
Bridges	–	C–	C	C	C	C+
Dams	–	D	D	D+	D	D
Drinking water	B–	D	D	D+	D	D
Energy	–	–	D+	D	D+	D+
Hazardous waste	D	D–	D+	D	D	D
Inland waterways	B–	–	D+	D–	D–	D–
Levees	–	–	–	–	D–	D–
Roads	C+	D–	D+	D	D–	D
Schools	D	F	D–	D	D	D
Solid waste	C–	C–	C+	C+	C+	B–
Transit	C–	C–	C–	D+	D	D
Wastewater	C	D+	D	D–	D–	D
Port	–	–	–	–	–	C
Average value of America's infrastructure grades	C	D	D+	D	D	D+
Improvement cost	–	–	$1.3 trillion	$1.6 trillion	$2.2 trillion	$3.6 trillion

A = Exceptional: Fit for future, B = Good: Adequate for now, C = Mediocre: Requires attention, D = Poor: At risk, F= Falling/Critical: Unfit for purpose.

Source: American Society of Civil Engineers. 2013. *2013 Report Card for America's Infrastructure*. Reston.

Figure 6.1: Maintenance and Replacement Cost of Infrastructure Evaluated by MLIT



Note: The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) estimates the maintenance and replacement cost of infrastructure including roads, ports, airports, public rental housing, sewage, city parks, rivers, and coastal management facilities in MLIT white papers.

Source: Ministry of Land, Infrastructure, Transport, and Tourism.

6.1.3 Practical Procedure of Infrastructure Maintenance

6.1.3.1 Procedure of Asset Management

Infrastructure maintenance requires a good plan that is steadily executed. Asset management has received attention as the methodology for doing this.

Asset management originally referred to investment activities aiming to maximize individual financial assets such as deposits and stocks by considering risk management and profitability. The idea and methods have recently been applied to infrastructure operation and maintenance. Asset management means a series of maintenance activities that try to maximize the asset value of infrastructure.

The key concept of asset management is preventive maintenance management. In conventional maintenance methods, we collect information on damage and deterioration of infrastructure through periodic examinations and repair them palliatively. On the other hand, predictive maintenance management requires us to forecast the future situation of infrastructure based on damage factors and deterioration mechanisms of facilities and to repair them in advance by making good use of the latest technology. The procedure of asset management defined by the International Organization for Standardization (ISO) is as follows (This management approach is abbreviated as PDCA, or plan–do–check–act).

Step 1: Plan

- Set management goal and financial condition
- Examine, judge, and monitor
- Forecast life cycle cost (LCC) and decide management level
- Calculate necessary maintenance and repair cost
- Propose priority for repairs
- Make budget
- Make maintenance and repair plan

Step 2: Do

- Execute maintenance and repair

Step 3: Check

- Carry out ex post evaluation of maintenance and repair plan
- Update asset information

Step 4: Act

- Review and revise maintenance and repair policy

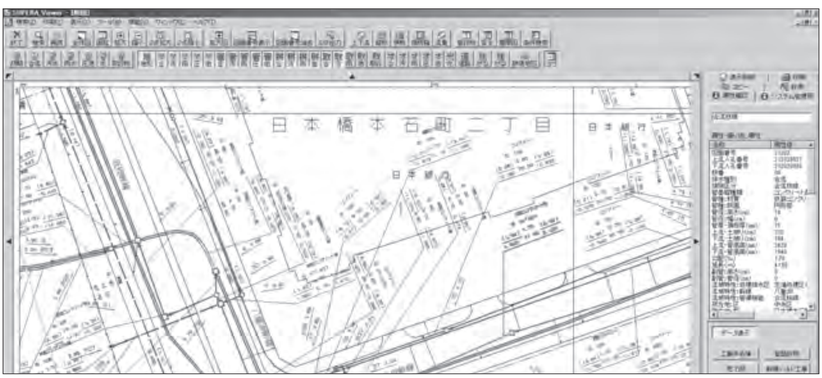
6.1.3.2 Centralized Management of Facility Data

In preventive maintenance management, planning, the first step of the asset management procedure, has a high value. When planning, we make a maintenance and repair plan and forecast the replacement demand and LCC.

Monitoring facility conditions is essential. We should confirm the current situation of facility deterioration. Facility name, location, and construction year are required as basic information, in addition to drawing and specification, construction records, and designers as construction material, and checking records, diagnostic information, and maintenance log as maintenance material. Previously, these pieces of information have been recorded on paper, but they are now recorded in digital format.

The Tokyo Metropolitan Government Bureau of Sewerage, for example, collects information on the type, extent, and scale of damage in sewerage pipes, including image data recorded by a mirror type video camera (a special camera that can capture 360-degree images). As the information can be accessed under a centralized management system, it is utilized for operation and maintenance in preventive maintenance management (Figure 6.2).

Figure 6.2: Ledger Information System of Tokyo Metropolitan Government Bureau of Sewerage (Example of a Screen)



Source: Tokyo Metropolitan Government Bureau.

6.1.3.3 Examination and Monitoring

Inspection work including monitoring of infrastructure facility conditions is classified into (i) periodic inspection with visual confirmation, (ii) usual inspection requiring some expertise, and (iii) technical inspection with high-level judgment. Among these inspections, periodic inspection is the most fundamental asset management system being used by many municipalities and private operators. Recently, management systems using sonic waves, electromagnetic waves, or infrared rays as well as conventional visual confirmation have been developed.

The Tokyo Metropolitan Government Bureau of Sewerage is required to take measures against aging bridge structures because the proportion of bridges over 50 years old in Tokyo is higher than that of the national average. The Tokyo Metropolitan Government conducts the following three types of examinations for monitoring bridge structures.

The first examination is daily inspection. Staff check balustrades, fences, pavements, joint steps, and abnormal sounds during road patrols. The second examination is periodic inspection, done every 5 years. Construction consultants examine cracks, decay, distortion, exfoliation, leakage, and abnormal sounds in a close visual inspection. The third examination is emergency inspection, conducted after incidents such as big earthquakes. In the case of a big earthquake, staff visually inspect movement, slope, deformation, and buckling of facilities by using patrol cars.

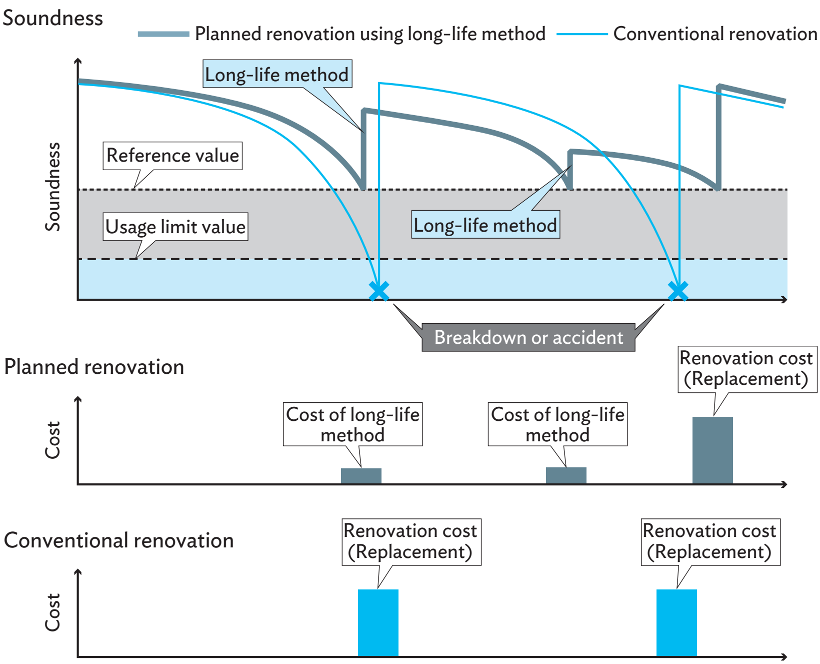
New technology has been introduced into the inspection methods. Conventional visual observations are not able to discern fatigue cracks and welding defects of metal piers/girders, cavities of concrete elements, and tension in suspension structures. To solve these problems, new technology has been introduced, such as ultrasonic waves and eddy current flaw detection tests for steel materials and infrared tests for concrete.

6.1.3.4 Deterioration Forecast and Life Cycle Cost Estimation

The key to preventive maintenance management is forecasting deterioration. The first step is estimating the deterioration curve. Operators decide the curve by using the latest knowledge including logical and empirical formulas, field survey data, and experts' knowledge. The deterioration curve is usually estimated with some variance because the progress of the deterioration depends on factors like environmental conditions, material characteristics, and countermeasures.

The maintenance method and period are determined based on the deterioration forecast. Several scenarios are usually considered, and the LCC of the facility is calculated for each scenario. The LCC, as described in Chapter 4, is one of the economic evaluation methods for infrastructure facilities. It consists of (i) initial cost, (ii) operation and maintenance cost, and (iii) cost of repairs, replacement, and disposal. Generally, consecutive minor repairs with small deterioration add up to a smaller LCC than a single large repair for almost broken structures. The maintenance scenario with the smallest LCC is selected. Based on this scenario, maintenance management is carried out (Figure 6.3).

Figure 6.3: Reduction of Life Cycle Cost Using Long-Life Method (Example of Sewerage)



Source: Ministry of Land, Infrastructure, Transport, and Tourism.

6.1.4 Advanced Cases

6.1.4.1 Maintenance of High-Pressure Trunk Pipeline by Tokyo Gas

There are three types of gas pipeline: high, medium, and low pressure. Tokyo Gas conducts maintenance based on the type for a long-term stable gas supply. In the case of a low-pressure gas pipeline, the old ones should be replaced based on the guideline regulated by the Ministry of Economy, Trade, and Industry and the self-maintenance direction regulated by the Japan Gas Association. Tokyo Gas applies a unique advanced method for high-pressure trunk pipelines, shown as follows (Figure 6.4).

First, they carry out periodic inspections and make an asset register. For facilities with aging deterioration, they make a maintenance plan and prioritize measures considering cost effectiveness.

Figure 6.4: Gas Facility Management GIS (Mapping System) by Tokyo Gas

Source: Tokyo Gas Engineering Solutions.

They developed an original database system that includes electronic data on their asset status. Drawings of the facility are converted to digital data. They set up remote monitoring devices for the flow and temperature of gas at each facility.

Valve and decompression facilities essential for security and stable supply can be controlled remotely. Information on maintenance such as replacements is recorded in the database.

One characteristic of the maintenance activities for high-pressure trunk pipelines is route patrols. High-pressure trunk pipelines are often laid under main roads. During route patrols, staff drive patrol cars along the main road, examining the road condition and confirming whether there is any construction without advance notice. The combination of digitalization and human observation contributes to optimal maintenance.

6.1.4.2 Maintenance Management of Tōkaidō Shinkansen

Maintenance work on railway facilities can be divided into periodic routine maintenance work for tracks and medium- and long-term maintenance work against deterioration of materials or natural disasters.

In shinkansen maintenance, a special train for dynamic inspection (called Doctor Yellow) runs all the sections at the operating speed.

Doctor Yellow. This shinkansen electrical and track inspection train runs regularly to detect needed repairs (photo by Central Japan Railway Company).

Doctor Yellow runs every 10 days and inspects the tracks and electrical and signal facilities by checking rail distortion, overhead lines, and signal current. The obtained data are immediately analyzed, and necessary repair places are detected.

Visual inspections of civil structures are carried out every 2 years. They identify repair places which need more detailed inspection and carry out special inspections for checking fatigue and deterioration.

There are two approaches for civil engineering structure maintenance. The first approach is to repair and reinforce in advance. If they find one problem in the structure, they carry out maintenance work in advance for other structures in which problems have not yet appeared as well as this structure. If they find one place needing repair, they believe that other places would need the same places repaired as the shinkansen civil engineering structures were constructed at almost the same time.

The second approach is preventive maintenance management. They conduct preventive maintenance for the parts of steel bridges or reinforced concrete structures that would have problems in order to keep these facilities available. For example, the neutralization depth of concrete is formulated based on the investigation results forecast and surface protection is arranged as preventive maintenance for suppressing the neutralization.

Since starting its service, the shinkansen has had no fatal accidents and has maintained punctual operations such that the average delay time is less than 30 seconds. This high-level safety and stability are supported by the successive and elaborate maintenance work on railway facilities.

6.1.4.3 Maintenance Management of the Hanshin Expressway

Expressways consist of not only road parts such as pavement and joints of bridges, but also subsidiary structures such as lights and drainage equipment. Inspection, maintenance, repair, and cleaning of these are done daily. Besides, repainting against aging deterioration, replacement of joint parts, and repaving should be required.

In the case of the Hanshin Expressway, the aging and deterioration will progress rapidly in the future because many of the lines were constructed in the 1960s and 1970s since the Tosabori–Minatomachi route started its service in 1964. Because of the limited maintenance budget, the Hanshin Expressway has asked experts' advice and introduced asset management early on.

Due to the characteristics of urban expressways, the bridge management system plays a central role in asset management. Specifically, they adopt an informatics management approach in which facility volume, inspection results, and repair records are required as input data, and budget, priority of repair, and management accounting information are submitted as output data.

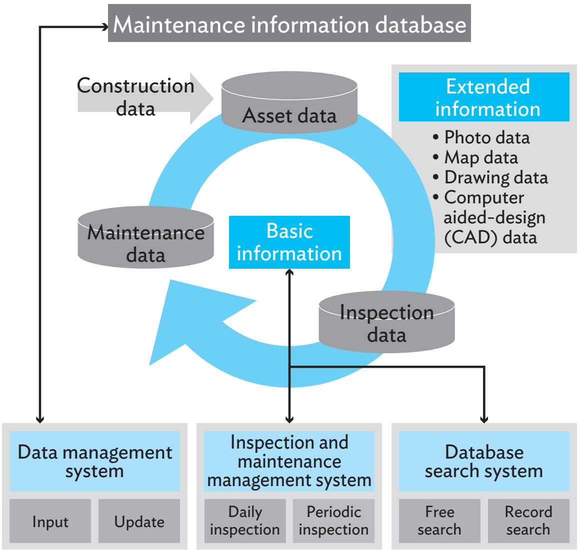
The future deterioration is estimated by the deterioration curve made from the accumulated inspection results and repair record data in the maintenance information database, and this prediction calculates the needed cost in the future. The Hanshin Expressway is building a system for pavement, painting, joint, slab, and concrete and steel structures.

The maintenance information database supports that system (Figure 6.5). The database accumulates and integrates the asset, inspection, and repair data, and contributes to supporting disaster response activities and developing traffic maintenance, as well as efficiently managing road structures.

6.1.4.4 Maintenance System of the Metropolitan Expressway

The road and structure maintenance support system, called the InfraDoctor of the Metropolitan Expressway Co., Ltd, is advanced in that it measures facility surfaces in a highly detailed three-dimensional manner using a laser scanner, inspects problems of the structures, and supports the making of inspection and repair plans (Figure 6.6).

Figure 6.5: Maintenance Information Database of Hanshin Expressway

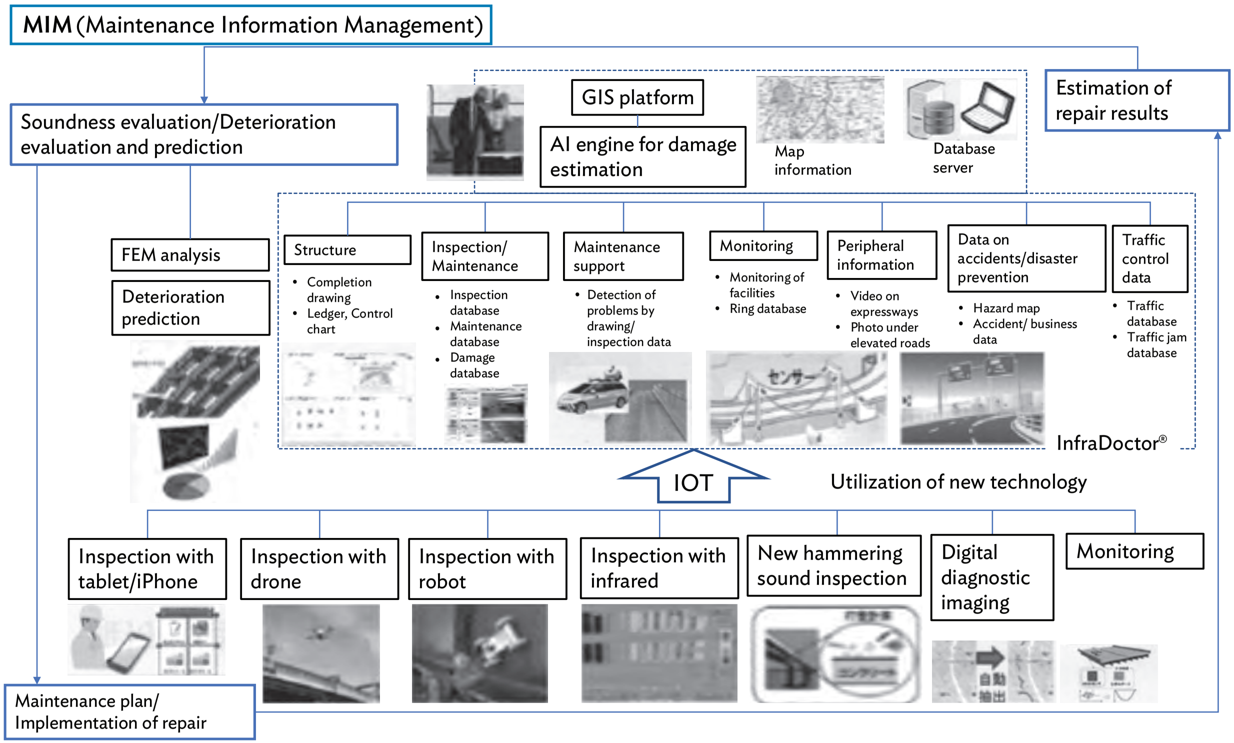


Source: Hanshin Expressway.

Three-dimensional point cloud data of road structures are acquired by laser scanning from running vehicles. The inspection areas are indicated on a map, and the system searches repair records, design drawings, and three-dimensional point cloud data. The system then visualizes them on a screen. The data acquired in different periods allow the system to automatically detect changes, and drastically decrease the work needed to be done by inspectors. Additionally, this three-dimensional point cloud data leads to generation of two- and three-dimensional computer-aided design drawings and measures the size of structures. Thus, the repair, design, or discussion of working methods can be done in offices without the need to measure again in the field.

With parallel usage of the information acquired as above and through other inspection methods, the soundness evaluation and deterioration prediction of facilities become more accurate and efficient. A series of asset management practices from inspection, deterioration evaluation, and prediction to repair can more efficiently happen.

Figure 6.6: Road and Structure Maintenance Support System: InfraDoctor of Metropolitan Expressway



AI = artificial intelligence, FEM = finite element method, GIS = geographic information system, IoT = Internet of things

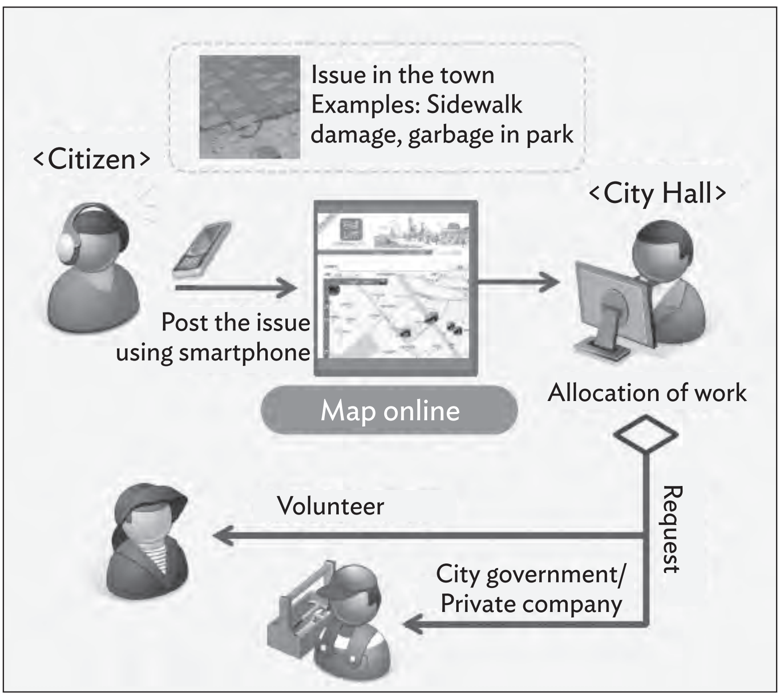
Source: Metropolitan Expressway.

6.1.4.5 Citizen–Government Collaboration Using Information and Communications Technology in "Chiba-Repo"

The maintenance management operations in local governments are suffering because staff numbers and budgets are insufficient to complete the necessary patrols and inspection. To address this problem, trials have begun in which the daily inspection of infrastructure is conducted with citizens' support using information and communication technology (ICT), which has been developing remarkably. One of these trials is the Chiba Citizen Collaborative Report (Chiba-Repo) in Chiba City, which started in August 2014 (Figure 6.7).

Chiba-Repo is a system by which citizens who discover infrastructure damage or problems such as damaged roads and broken playground equipment can take a photo with their smartphones and report it with locational information to the city office. The reported information is uniformly managed in the cloud, and the city office classifies and responds to each problem. Citizens can view the city office's response

Figure 6.7: "Chiba-Repo" (Chiba Citizen Collaborative Report)



Source: Chiba City, Chiba Prefecture.

to problems (checked, responding, and completed). For visualizing progress on raising and solving problems, it is expected to enhance the citizens' motivation to participate and government efficiency.

Chiba-Repo is also an interesting trial as an information sharing system to maintain the city's functions using the collaboration of citizens and government, or collaboration among citizens, and such systems are expected to develop in other cities.

6.2 Investment in Maintenance and Replacement of Infrastructure

6.2.1 Funding

In the case of pure public type infrastructure, operators are supported by a governmental budget that is provided for maintenance costs as necessary, as mentioned in Chapter 3. The operators of public–private mixed and private business type prepare their own budget for maintenance. Based on corporate business accounting rules, they accumulate reserved cash by facility depreciation.

6.2.1.1 Public Property Management: Pure Public Goods Type

Public (government) accounting applies for the management of infrastructure operated by administrative agencies, and it is basically impossible to reserve the budget for future maintenance. Maintenance expenses are included in operating budgets every year, and the expenditure for major repairs and replacements is budgeted for and executed when needed.

6.2.1.2 Depreciation: Public–Private Mixed and Private Business Type

When a business entity is a private company, it applies business accounting, and its capital for maintenance is basically funds reserved for depreciation.

However, the real maintenance cost is not always within the capital that the business entity internally reserves. Moreover, when it manages several pieces of infrastructure or makes new investments, it must determine the maintenance and replacement expenses comprehensively. When utilizing external funds, attention must be paid to the fact that interest rate management has a large influence on the management of the project entity.

6.2.2 Cases of Management and Replacement Investment

6.2.2.1 The Case of Japanese National Railways and Japan Railways

When infrastructure business entities consider the funding for maintaining facilities, the important points are to properly manage the total expenditure of new investment and maintenance and to balance internal and external procurement. While it seems obvious, due to the extremely large initial cost of infrastructure, it must be always recognized that there is the risk that the project might fail if the funds are not cautiously managed.

One example is the financial deterioration of the former Japanese National Railways. It first fell into a current account deficit in 1964, and the accumulative deficit continued to grow despite various managerial efforts. Japanese National Railways (JNR) was finally divided and privatized, detaching the lines that were in deficit. One of the causes of that deficit is widely known: the depreciation expenses had drastically increased.

In response to the expansion of transportation demand, JNR had intensively and massively invested based on magnificent plans: the first five-year plan from 1957 (investment of ¥600 billion), the second five-year plan from 1961 (¥1.35 trillion), and the third long-term plan from 1965 (¥1.42 trillion). The main contents of the first plan were to renew facilities and vehicles and promote electrification and dieselization. The second plan was mainly to construct the Tōkaidō Shinkansen, make the main route into a double line, and electrify lines. The third long-term plan included construction of the Sanyō Shinkansen, responding to commuting needs in big urban areas and strengthening security facilities. It was a massive investment including new construction, not limited to maintenance.

The business income of JNR was ¥570 billion in fiscal year 1963 and ¥600 billion in 1964. It can be said that JNR's capital investment in 10 years was about five times larger than its total yearly income. As a result, the depreciation cost, which was only ¥70 billion in fiscal year 1963, exceeded ¥150 billion in fiscal year 1967. Under that condition it became extremely difficult for JNR to make a profit.

Besides, the railway administration in those days did not contain subsidy systems for JNR. Thus, the funding methods for implementing the long-term plans were loans (Fiscal Investment and Loan Program [FILP] loans) and railway bonds (government-guaranteed bonds). Both are interest-bearing debt, and the cost of funds at that time was 7%, a heavy interest burden. The interest expense in fiscal year 1964 was

¥38.5 billion and reached ¥101.2 billion in fiscal 1967. A vicious circle began, where the interest payment required a new loan and the new loan increased the debt further with interest.

JNR came to face not only the difficulty in making a profit due to the increasing depreciation cost, but also the difficulty in maintaining cash flow because of the drastically increased debt with interest. This is one example in which the total investment control of maintenance and new construction investment, and the balance between internal and external funding, have fundamental importance in the management of infrastructure business.

By learning from that bitter experience, in the management of Japan Rail (JR) companies after privatization, the capital investment expenses (including maintenance and new investment) have been kept close to the depreciation expense level.

6.2.2.2 Elevated Railroad Project System and Usage of Additional Fare System: The Undergrounding Project of Keihan Electric Railway

Even in the private business type, public support may be applied for investment in infrastructure maintenance or replacement if its social usefulness is recognized. One example is the extension and undergrounding project of the Keihan Electric Railway Main Line in Kyoto City.

The Keihan Electric Railway main line connects Osaka and Kyoto and was originally running at ground level with Sanjō Station as the terminal. As the vehicle traffic volume had increased in Kyoto City, traffic congestion caused by train crossings became serious. At the same time, there was a new issue of extending the existing line from Sanjō Station to the northern areas to meet increased demand there.

The operating company planned two projects to address these two problems: to relocate 2.6 kilometers (km) of the main line between Tōfukuji and Sanjō underground, and to construct a new line between Sanjō and Demachiyanagi. The total cost of the two projects was estimated over ¥60 billion. That amount exceeded the range that the operating company could get finance on their own, so they decided to utilize the elevated railroad crossing project system and the additional fare system. The former is a system that allocates road development budget to efforts like railway elevation when they help facilitate road traffic. The latter is a system that allows an increase in the fee for a certain period to make up for the construction cost.

The elevated railroad crossing project system applied to the existing main line between Tōfukuji and Sanjō. Eight crossings were planned to be eliminated by this project. The estimated effect on traffic congestion was positively evaluated by the authorities. Due to the adoption of that system, the share of Keihan Electric Railway came to be 16.7% of the total cost of ¥60.5 billion, and the remainder was paid by the government (55.3%) and Kyoto City (28.0%).

The line to be newly constructed, Sanjō to Demachiyanagi, was planned as a different line from the existing one, and in the beginning the business entity was also planned to be established as a separate company. Afterwards, the operating company of the existing line decided to construct the new line as their own project. They applied for the additional fare system, which allowed them to reduce the burden of covering the estimated total project expenses of ¥65 billion. The additional fare system allows an operating entity to add an additional fare for a certain interval when allocating it to a specific use. In the case of this newly constructed Keihan Ōtō Line, ¥60 was added to the base fare of ¥150 for the chosen three stations. This additional fee looks small but has a big effect. At the end of fiscal 2015, the capital investment for the Ōtō Line was ¥46 billion and the cost of facility use and interest was ¥22.8 billion in total, so the accumulated expenses were ¥68.8 billion. On the other hand, the accumulative repayment from the additional fare was ¥20.1 billion and the repayment allocated from the base fare income was ¥1.1 billion. So, it can be said that the additional fare income contributed to redeeming about 30% of the project cost.

6.2.2.3 The Case of Tokyo Metro

Subway construction requires a large initial investment. It will take a long time before the operating entity can reap stable earnings after redemption of the initial investment. Many Japanese subway management companies suffer from deficits caused mainly by heavy redemption burdens and regulated low fees. Nevertheless, Tokyo Metro today is financially healthy; its operating profit margin is 25% and its capital adequacy ratio is around 40%. Teito Rapid Transit Authority, the predecessor of Tokyo Metro, had been investing intensively and massively during the period from the start of construction on the Marunouchi Line in 1954 to the opening of the newest Namboku Line in 1991. The capital cost was drastically increased, and the sum of the depreciation cost and interest occupied nearly 70% of their business income in 1970. Moreover, they experienced financial deficits for several years in the 1970s.

After that, however, the effects of many measures prevented further financial deterioration. These measures included the subsidy system for subway construction in 1962 and the railway development fund in 1990.

According to certain research, even more effective than these measures was the profitability of the Ginza Line (opened in 1927), which had already been redeemed.

Tokyo Metro has almost finished construction of new lines and is investing in facilities mainly to improve the quality. According to the figures for the fiscal year ending in March 2016, the operating income was ¥362.6 billion, the current net profit was ¥90 billion, and depreciation cost was ¥67 billion, so that about ¥100 billion was available for facility investment. In fact, the expenditure on facility investment at that time was ¥126.9 billion, mainly ¥48.8 billion (38%) for safety measures and ¥45.2 billion (36%) for passenger services. Safety measures include the construction of platform screen doors and seismic reinforcement, and passenger services spending is on improving physical accessibility and so on.

6.3 Operation Management of Infrastructure Projects

Infrastructure enters the operation and management step after construction and starting to offer services. Although the details of operation differ depending on the type of infrastructure, operation and management matters common to any type are (i) facility operation, (ii) demand creation, (iii) risk management, and (iv) business management.

Facility operation is a series of tasks for which the main function is to provide proper services to facility users. An airport, for example, does not execute its function until operations such as control and logistics processes are performed.

Demand creation means activities to promote the use of infrastructure. The social and economic effects as well as the revenue of the operating entities of transportation infrastructure and so on will increase as the number of users increases.

Risk management has two aspects: one mitigating many kinds of risk that impede the proper operation of infrastructure, and the other is preventing or reducing degradation of infrastructure when major disasters happen.

Business management is the necessary management for providing sustainable services mainly in public–private mixed and private business types.

The outline of each management task and several examples are provided in the next section.

6.3.1 Facility Operation: Digitizing Infrastructure

Generally, the number of users of huge infrastructure systems is enormous, meaning that merely collecting fares is labor-intensive. Moreover, big and quick data management is required in monitoring water flowing upstream and downstream in class A rivers, arrival and departure management in airports, and railway operating management in big urban areas.

ICT has already been introduced in many fields in infrastructure management. Infrastructure operation itself is a characteristic of the "equipment industry," where fixed costs occupy a large proportion. In contrast, the operation field can now be called an "information industry." While infrastructure operation is without a doubt human work, the enormous information systems have become a necessity because the quantity of information has grown to be so large.

6.3.1.1 Airports: Air Traffic Flow Management and Airspace Management

The aim of airport operation is to realize safe and on-time flights. Recently, congestion in the sky is notable. For example, Haneda Airport with four runways has 1,200 arrivals and departures daily. (The largest number of arrivals and departures in the world is 2,600 per day in Hartsfield–Jackson Atlanta International Airport in the US). Each runway is supposed to have at least a 2-minute interval between arrival and departure at the most congested times, and this is denser than the operation schedule of the Yamanote Line, the city rail with the shortest operation interval in the Tokyo Metropolitan Area. Moreover, the ground speed of jumbo jets at arrival and departure time reaches 200 to 300 km/hour, so management requires keen attention.

An air traffic control information processing system supports Japan's airport management. This system, using flight operating plans, airplanes' position and speed information, and the status of airspace usage as input data, estimates the appropriate air traffic at each airport and shows traffic control information to management officers. This system consists of several subsystems.

The flight data management system integrates and shares aircraft flight plans, and offers flight plan information to the controllers at each airport.

Since aircraft fly long distances at high speed, it is important to grasp the position information, which is tracked and controlled by integrated monitoring systems. Radar at each airport and across the country grasp the position and ground speed of airplanes, and the information acquired by them is provided to control offices through several computer systems.

Furthermore, the positions above the Pacific Ocean are calculated and displayed by another dedicated system.

The sky area in which airplanes can fly is called airspace, and its status must be known for secure flight traffic. Accordingly, an airspace management system integrally manages airspace utilization information such as civil training and testing areas, Japan Self-Defense Forces limited areas, and rocket launching, and provides the information to the related organizations to support the coordination of airspace usage.

Additionally, the air traffic flow management system integrally analyzes the information, estimating the proper air traffic and providing it to each airport to prevent overconcentration of air traffic on specific air routes and airports.

Airport operations use many information systems as well as systems related to control work. The above internal systems are connected to the systems of the Japan Meteorological Agency, the Ministry of Defense, and each airline, which process many kinds of information including the flight plans needed for airplane operation, weather, search, and rescue. These integrated systems support the work of the Civil Aviation Bureau as well as the offices and branches of each airport.

At airports, not only airplane operation, but customs clearance, guide display, and logistics operations are also supported by information systems.

6.3.1.2 Ports: Terminal Operations

Port operations invest heavily in the computerization of logistics operation done after docking at piers. While the information systems supporting large international ports have different characteristics in each country and harbor, here the case of the Singapore Port Authority is explained because its structure is relatively understandable.

The Port of Singapore has the second largest amount of activity in the world following Shanghai Port and is connected to 600 ports in 123 countries, whose average calling is 90 per day. The port can handle about 60,000 20-foot equivalent unit (TEU) containers. One of its characteristics is that about 85% of the landed cargo is transshipment. PSA International Pte Ltd (PSA) is in charge of port operations. They have invested in computerization mainly of three sections: electronic transactions, terminal operations, and terminal gate management.

The electrical transaction system, called PORTNET, connects shipping companies in Singapore, logistic companies, non-vessel operating common carriers (NVOCCs; these are logistic companies not owning means of transport such as ships), and government organizations and registers over 9,000 users. This system allows users to order container berths, arrange transshipment, maximize slot usage, exchange information among alliance ship companies, declare customs, and pay tariffs.

The system CITOS supports terminal operations. Through this system, the central control room can simultaneously manage many tasks in the container yard and give work directions to each operator. For example, the unloaded containers, based on the information in PORTNET, can be put in an optimal place considering the cargo weight, destination, and need for special measures.

The information system in the terminal gate controls gate passage of 8,000 trucks per day in Singapore Port. At peak times, 700 trucks per hour pass through the terminal gate. The gate checking process is to examine the driver's license, measure the truck weight, and confirm the container numbers. The process has been automated and now only takes 25 seconds per truck.

6.3.1.3 Railways: Operating Management System

Railway operations today are, of course, fully supported by information systems. The real time exchange of information as well as remote control is vital for operating high-speed and urban railway networks to realize the frequent and smooth running of many trains. While there are many examples, the case of East Japan Railway Company is explained below.

It was Nagoya Railroad and Keikyū Corporation in 1954 that first realized the concept of centrally controlling railway operations in Japan. The computer system introduced at that time was called the Centralized Traffic Control (CTC). CTC simultaneously displayed real-time railway operations and branch operations of each station. Tōkaidō Shinkansen, which opened in 1964, first introduced CTC on all lines. However, even in 1987 when JR was established, 44% of the 7,000 km of conventional railroads in the area of East Japan Railway Company was not covered by a computer system that could monitor every position of trains in operation. The system introduced in 1972, the Computer Aided Traffic Control System (COMTRAC) automatically configured the path of the train based on the input timetable. That means that signal control, which was manual during the period when CTC was used, became automatic after COMTRAC was introduced. Computerized Safety, Maintenance, and Operation Systems of Shinkansen (COSMOS), the successor of COMTRAC, is utilized for operating shinkansen in the areas of East Japan Railway Company. The function of COSMOS is broader and it covers operating management, car maintenance, instrument maintenance, maintenance work management, electric system control, concentrated information monitoring, and work management in yards as well as transport management.

Programmed Route Control (PRC) was a computer system for automating schedule management of conventional railroad lines including signal control. PRC was first introduced to the Musashino Line in 1976 and was later applied to the Tōhoku Shinkansen. However, it could not control train handling inside stations, for example direction change, and the need for fundamental improvements was recognized.

Currently, the East Japan Railway Company uses the Autonomous Decentralized Transport Operation Control System (ATOS), which solved the problems of CTC and PRC. ATOS consists of three classes: the central apparatus, the district apparatus, and the station apparatus. Its comprehensive functions cover schedule management, operation management, automatic direction control, announcements for passengers, and maintenance work management. These comprehensive information systems are vital for realizing the dense and frequent railway network operations in the metropolitan area.

6.3.1.4 Roads: Intelligent Transportation Systems

Roads, unlike railways, ports, and airports, do not directly control users' (vehicle or pedestrian) behavior. Thus, the road transport field has promoted ICT, of which the main aims are completely smooth road usage through indirect control of traffic flow by providing real-time information and maintaining users' safety.

A computerized system in road transport is generally called an intelligent transportation system (ITS). These systems have a variety of functions including enhancement of navigation systems, electronic toll collection (ETC) systems, support of safe driving, parking lot navigation, and providing information on local weather based on taxi wiper usage information.

A universal traffic management system, promoted by Japan's National Police Agency, is one case of an ITS supporting infrastructure utilization. This is a system that analyzes and provides the road usage information acquired from optical vehicle sensors (optical beacons) on the street and aids real-time traffic management. This system benefits the traffic control system including signal control as well as a system to provide traffic congestion information to drivers. Plus, it has enabled a public vehicle priority system that supports the smooth movement of public vehicles with specialized IDs, a vehicle operating management system that provides driving data to companies using roads, and an inflow control system using roadside gas and noise data that is effective for preventing road congestion.

ITS promotion has developed under international collaboration. The ITS World Congress, held every year, attracts many participants who actively share information. (The Tokyo conference in 2013 was attended by 3,935 people from 69 countries).

6.3.1.5 Rivers: Monitoring and Operation

Computerization has also developed in river management. A unified river information system was constructed under the leadership of Japan's national government.

The unified river information system handles not only telemeter data (data in 17,000 observatories of prefectures and MLIT), but also rainfall data (9,000 observatories), water level data (5,500 observatories), radar data, typhoon data, forecast and alarm messages, and weather information (from the Automated Meteorological Data Acquisition System, AMeDAS). This system overlays real-time and past data and then provides it to river managers. As the fundamental information database on national and broad disaster management, the information provided through the internet is used by the public as well as river managers.

Based on a centralized database, the computerization of the management of each river has progressed. One example is the case of the Shinano River Management Office. This office maintains 164 facilities in 68 places such as sluice gates, sluice pipes, and pumping and drainage stations including the large facilities of an overflow weir and movable weir at Ōkōzu. A computerized mechanical system has been constructed to monitor and remotely control these facilities.

This system monitors the state of operations and problems of each instrument, displays water level changes and system failures, and records those states. It automatically reports the records, generates automated voice calls (connecting office, branch, and field), and enables remote control of river management facilities. It also has a web camera that takes images of the operating room and checks the operation board inside and the operator's state at the sluice gate, as well as a remote operating camera that monitors the transition of river management facilities.

This automated river management, remote control, and computerization contribute to the safety of operators and stable operation in emergencies as well as simply improving operational efficiency.

6.3.1.6 Power Supply: Control of Power Generation, System, and Distribution

A power supply network, as infrastructure, is the group of instruments that connects various power plants and substations by a transmission network, and precisely supplies power to demand areas. The operation of this network is supported by a computerized power generation control system, a grid control system, and a power distribution control system.

The power generation control system, as its name suggests, is the system that monitors and accurately controls various instruments including boilers, turbines, and generators in a power plant. The grid control system monitors and controls the provision of power to customers via the most effective and stable route from several plants, and to minimize power outages by quickly switching to a detour route when accidents cause power cuts.

As electric power cannot be stored, these systems always monitor the demand change and control the supply in almost real-time. This is called load-dispatch instruction, where electric power companies indicate the amount of power generation to each plant based on demand observation. In addition to traditional supply management, supply and demand management systems for new types of power have recently become more important to effectively utilize electricity from solar and wind power.

6.3.2 Demand Creation

Infrastructure cannot contribute to society unless it is used. This is particularly noticeable in the transport and energy fields. It is essential to increase income from fees to improve profitability in public–private mixed and private business types. Accordingly, business operators make many efforts to increase infrastructure usage—that is, to create demand.

6.3.2.1 Ground Transport: Destination Management

It is typical in ground transport such as railways and roads that infrastructure is constructed in the areas with demand, but various ideas exist for further demand creation. Demand creation in transport is to increase trips, and the increase in the number of people traveling leads to economic development in the region.

In urban railways, whose main objective is to get commuting demand, railway companies construct recreation facilities strategically in suburbs that are located in the opposite direction of the central business districts, generating trips that take people in the reverse direction to commuting. The Takarazuka Theatre built by Hankyu Corporation and the baseball stadium built by Seibu Railway Co., Ltd. are good examples.

We have seen many examples of industrial complexes and outlet stores being constructed around expressway interchanges. They are not built by road companies. Local municipalities attract these business facilities and sometimes help the facility managing companies, and as a result the number of trips increases and the local community is revitalized. Road companies cooperate with these local activities in many aspects.

Recently, it is commonly recognized that the road itself, if it offers an enjoyable drive and beautiful scenery, has the effect of attracting visitors from outside the region. The idea that such roads should be more recognized and promoted has become common among officials, academia, local leaders, and so on. In the US, laws for the official designation of such sightseeing roads have been developed since the 1980s. The law states six evaluation points: landscape, history, nature, culture, recreation, and archeology. The roads that exhibit one point out of the six are officially approved as National Scenic Byways, and the roads exhibiting two or more points are approved as All American Roads and broadly made known. As a similar trial, the Scenic Byway Japan, a council supported by the Ministry of Land, Infrastructure, Transportation, and Tourism has selected over 130 routes as model routes in Japan.

These efforts to create demand are sometimes discussed as "destination management" in the relationship with tourism. Destination management means finding and evaluating the attractive resources in a community, combining them with transport infrastructure (accessibility) or hospitality, and advertising them, leading to an increase in visitors. Recently, more local regions in Japan have established corporations called destination management or marketing organizations as the central organization to enhance these activities as part of tourism promotion. Transportation infrastructure operating entities have had more opportunities to contribute to increasing the number of visitors through collaboration with these organizations.

6.3.2.2 Airports and Ports: Port Sales

Activities promoting utilization of ports and airports are called "port sales" and "airport sales." The methodology, though different at each airport or port, generally consists of meetings with potential airport or port users, exhibiting in big shows, and company visits. Company visits are often "top sales" (the president of the port authority or local municipality visits the head of a company) visiting the shipping and aviation companies and the consignor companies.

For example, the Narita International Airport Corporation tries to make the most of airport sales opportunities such as the Routes Asia Conference, big exhibitions in the aviation field, the annual meeting of the International Air Transport Association (IATA), schedule coordination conferences, and the World Low Cost Airline Conference (WLCAC). Using these opportunities, the Narita International Airport Corporation contacts worldwide aviation companies to convince them to open regular routes to Narita Airport. In addition to aviation events, the Narita International Airport Corporation exhibits at tourism events such as the Japan Association of Travel Agents to exchange ideas with entities involved in tourism, like the tourism bureaus and travel agencies of different countries.

6.3.3 Risk Management

6.3.3.1 Risk in Infrastructure Projects

Infrastructure generally has a long life, in some cases more than 100 years, and many events including accidents happen during that time. Since infrastructure investment is ordinarily costly, an accident may make for costly restoration and reconstruction. These risks have been systematized from many perspectives; one example is shown in Table 6.2. This table was made based on the cases of infrastructure companies' export efforts to Asian countries using the public–private partnership (PPP) methodology. For that reason, some elements such as exchange risk do not apply to domestic projects. Still, the table will help with an overall understanding of the risks in the infrastructure business.

In this chapter, we focus on "general" and "operation" in the table because it covers the operation step in the infrastructure business. Generally business entities cannot prevent these general risks, such as political risk, socioeconomic risk (risk mainly from macroeconomic changes), and natural disaster risk. What they can do is to recognize the probability that these risks will occur and take measures to minimize damage when risks appear. In contrast, the probability of occurrence of accidents in the "operation" phase can be reduced by management efforts. Taking proper preventive measures matching the characteristics of the project is essential. Operational risks include demand risk, risk of providing a low standard of service, operational expenditure risk, maintenance risk, and human resource and labor risk.

The infrastructure business typically has little freedom in fee setting due to various regulations. (Details on pricing are in the next section.) The initial investment is quite large, and the biggest problem before the initial investment is made back is naturally financial risk such as the risk of increased interest rates.

6.3.3.2 Risk Measurements

Risk control starts with risk evaluation. Risk evaluation means predicting the scale and frequency of expected risk impact on projects. This is also called risk quantification. The evaluation perspective differs depending

Table 6.2: Examples of Risks Related to Infrastructure Business

Phase in Which Risk Occurs	Risk Type	Cases
All Phases	Political risk	Political resistance to the project, changes in laws and regulations, changes in the project environment due to government changes, outbreak of regional conflicts
	Economic risk	Increase in borrowing costs due to surging interest rates, deterioration in business profitability due to inflation, exchange rate risk
	Natural disaster	Damage to equipment due to occurrence of natural disaster, recovery cost, damage compensation
Construction	Land acquisition	Business delay due to land acquisition risk, site state risk (ground, soil contamination, etc.), business licensing risk, environmental evaluation, etc.; business delay due to excavation, land acquisition risk, land access risk, protestor risk, surplus land disposal risk
	Construction	Risk of construction subcontracting risk, reliability of subcontractor, risk of rising project cost, risk of specification change due to public institution (orderer) circumstances, certainty of securing income during construction period, technical failure, unexpected natural conditions (soft ground, etc.)
	Completion	Delay risk due to subcontractors, delay risk due to other causes, risk of exposure of design/equipment/technology not meeting the required level
Operation and Management	Operational risk	Demand risk, network risk (such as improvement of competing facilities), risk related to payment from public institutions (sub-sovereign risk, etc.), low quality service provision risk, operating expenses (OPEX) risk, maintenance management risk, human resources risk/worker risk
	Discontinuation risk	Project company bankruptcy risk, risk of project suspension due to the plans of public agencies, damage occurrence risk due to force majeure, risk relating to distribution of residual value

Source: Ministry of Economic, Trade and Industry. 2016. *Interim Report of Asia Infra Finance Study Group*.

on the project property. Figure 6.8 shows one model. In this figure, the horizontal axis is event frequency and the vertical axis is impact scale of risk, and many expected risks are plotted. The figure implies that risks with low frequency and small impact should be basically solved by operation, and it is better to consider insurance against risks with big impact, whether high or low in frequency.

It is important for decision making to understand each management methodology for each risk feature. The arrangement of this topic is shown in Figure 6.9.

Risk management generally consists of risk control and risk finance. Risk control targets the accidents for which the business entity side can control the frequency of occurrence and its impact. Operational

Figure 6.8: Example of Risk Mapping: Risk Factors and Response Policy

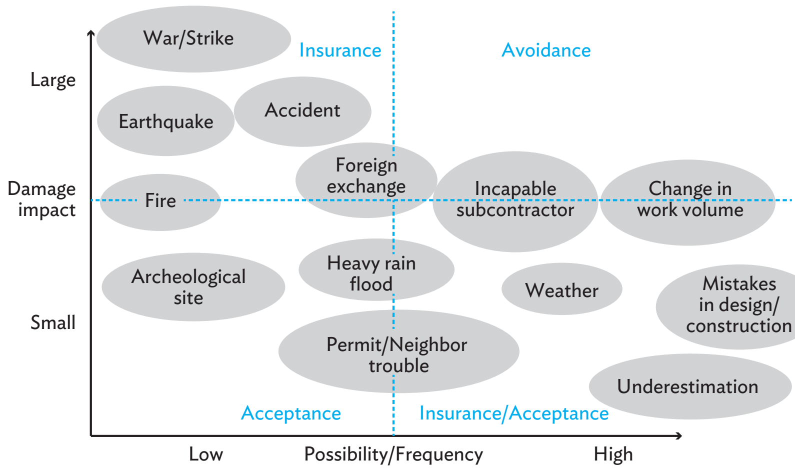
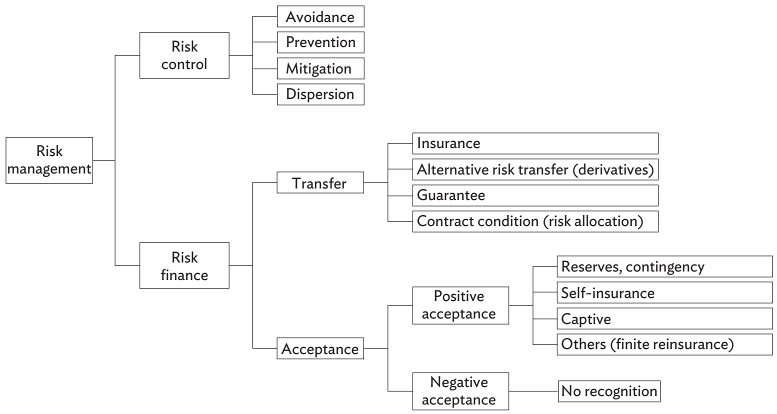


Figure 6.9: Risk Management System Example



Source: Policy Research Institute for Land, Infrastructure, Transport and Tourism, Ministry of Land, Infrastructure, Transport and Tourism. *The Study on Risk in Infrastructure Development*.

expenditure risk and maintenance risk, mentioned before, certainly apply to this. Risk finance is the methodology for compensating for expected financial damage against unavoidable risks. Insurance and accrual of reserves can be considered as effective methods.

Insurance has a financially important role in risk finance. Though it is a not recent case, Kyūshū Railway Company encountered a deficit crisis for the first time after privatization in March 1994.

The restoration cost and income reduction reached a loss of about ¥10.8 billion caused by heavy rain and a typhoon disaster in the summer of the previous year. About ¥6 billion of that loss, excluding the restoration cost of redeemed assets from the total loss, had a negative influence on the company's financial account. Ultimately, over ¥300 million profit was achieved mainly because ¥1 billion in disaster insurance money was received. Japanese National Railways was nationally owned and was not the target of private property insurance. The first insurance for infrastructure in Japan was commercialized by several insurance companies after the privatization of Japanese National Railways and launched was in May 1991. It can be said that Kyūshū Railway Company was saved by an income source that did not exist at the time of Japanese National Railways.

6.3.4 Business Management

6.3.4.1 Operation Index and Finance Management

The management stability of the operating entity is an important factor for the persistence of infrastructure projects. Financial management based on the proper operation indices is essential.

A business entity can exist only while the "bloodstream" of funds continues. A business entity would come to an end if the operation cost could not be paid or debt repayment became impossible. The pure public goods type infrastructure exists by the funding stream generated by the right of tax collection, so the activity for its financing is almost synonymous with budget acquisition. On the other hand, the public–private mixed type and private business type need to acquire the necessary funds from other entities based on project profitability. They differ from the pure public goods type in that they must generate funding by themselves. The essential point is that the capital cost is incurred to the business entity. Capital cost is mainly paying back interest. Many failures of infrastructure projects happen because it becomes impossible to acquire the needed funds or the business entities are bankrupted or withdraw because they cannot properly manage capital cost.

Debt and interest tend to be enormous in infrastructure projects due to their large initial investment, and the management of railway projects is sometimes described as "competition with interest rates." This tendency is true of expressways, energy companies, and other equipment type industries as well as railways. The capital cost problems in the public–private mixed type and private business type will be discussed below.

The state of management condition can be understood based on financial statements. Methods for raising funds mainly consist of debt and shareholder equity. The former is borrowing or corporate bonds, and the principal and interest must be returned. The latter does not require repayment but requires payment of dividends to the investors. Interest payment is a cost, and dividend payment is allocation of profits. More payment of interest increases cost, suppresses profits, and influences dividends. A lower dividend payout ratio might also influence stock prices. The infrastructure business involved large depreciation costs and a high fixed cost ratio including labor cost. On the other hand, it has little freedom to increase income due to regulation of fees, and it is difficult to expect high profitability. Under this condition, changes of interest payment have a large influence on financial management.

It is fundamental for healthy management to first set proper profit goals considering dividends to shareholders. Then they must decide to manage operating expenses to achieve that goal. Payment of interest should be within that cost frame.

As the status of interest-bearing loans is highly related to corporate financial soundness, many indices for evaluating it have been developed. One example is the debt equity ratio, which is the proportion of debt compared with equity. Normally, less than 1 indicates financial stability.

However, it is difficult to maintain sound project management because many unpredictable elements exist. On the risks disrupting management outlined in Table 6.2, financial risk is one of the crucial points, as well as natural disasters and declining demand.

6.3.4.2 Pricing

Infrastructure usage fees are subject to public regulation, as described in Chapter 3. Many ideas have been proposed to achieve Ramsey pricing.

One idea is called the average cost pricing formation principle, which is a method to set a sales unit price by dividing all expenses required for the relevant infrastructure business by the assumed usage amount and adding a profit portion considered appropriate. In fact, this idea was applied to the electric power supply business and the like and was called the comprehensive cost principle or full-cost pricing. Infrastructure business operators are looking for an accessible fee level that encourages wider use of infrastructure while referring to the average cost price formation principle.

For an example of railway management, in the areas with low transport density, if you apply the principle of average cost pricing, the fare should be at a very high level because the number of users is small. If so, there is a problem from the viewpoint that infrastructure has a public mission to support the livelihoods of many people and to enhance the convenience of the society. Thus, in many cases, the usage fees are set to the level that ordinary users can afford, and to achieve this the public assistance for construction costs and operating costs are examined separately. There is what is called a two-part tariff in a method explicitly combining fixed cost and marginal cost. This is a combination of the basic fee and the metered fee. Generally, the basic fee is the fixed expenses portion and the metered fee is the amount equivalent to the marginal cost. This concept is more applicable to infrastructure projects where the fixed cost is relatively small (for example, telecommunications) compared to other infrastructure projects.

Regulations that suppress excessive profit-seeking by monopolist companies and make these companies pursue management efficiency are called incentive regulations. These include a license bidding system, a yardstick system, and a price cap regulation.

The license bidding system creates a virtual competitive state by setting an expiration date on the project license. The infrastructure business entity that aims to continue its license must raise management efficiency and avoid pursuing excessive profit in order to beat the competitors who are hoping to win the next bidding. This is the theoretical basis of such practices as the franchise bidding introduced in railway management in the UK.

In the yardstick method, a common evaluation index is set for a group of companies under similar conditions, and the fee of each company is regulated based on that index. For example, a method such as setting a regulated fee between the best and worst performing companies could be used after comparing management efficiencies among monopolist companies in multiple regions. By doing so, we believe that monopolist companies with high management efficiency are highly profitable and monopolist companies with inefficiency become low-profit, so indirectly competition will arise, and efficiency will be promoted.

Price cap regulation sets the price ceiling and makes all profits attributable to enterprises. Companies can gain as much profit as can improve management efficiency. A level close to the Ramsey price can be realized by appropriately reviewing the upper limit price assuming the range of appropriate profit.

As you can see, the main point of the relationship between entry/exit regulation and price regulation is—in order to eliminate disastrous competition and adverse effects of natural monopolies, and as a result to improve the management efficiency of any business entity that gained monopoly status—to make fee restrictions by creating virtual or indirect competitive relationships.

6.3.4.3 Importance and Management of Interest in Infrastructure Projects: The Case of Expressways

The repayment of the accumulative debts in the former Japan Highway Public Corporation is a case showing the importance of interest management in infrastructure projects. The Japan Expressway Holding and Debt Repayment Agency, which has expressway facilities according to the separation policy of property possession and operation policy, succeeded in repaying the debts of that public corporation. The privatized expressway companies pay the facility rent to that governmental agency. The agency repays the debt inherited from the ex-highway public corporations, using the rent as funds. It was said that the total debt at that time was ¥40 trillion and the average interest rate was about 4% with a repayment period of 45 years. This was a massive scale repayment for which the total amount would have been ¥86 trillion in principal and interest equal repayment assuming a constant interest rate and a 1% change of the interest rate would lead to a ¥10 trillion change in repayment.

Although the risk of increased interest was extremely high, the interest on fiscal investment and the government loan program, the majority of the debts, had been less than 4% during the 10 years just before privatization, and normally the rate was slightly over 1%. Utilizing the low interest rate environment, the new agency converted the debts, including the debts from fiscal investment and loans taken when the interest rate was high, to lower the interest debt. This interest management approach made it possible to drastically shorten the redemption period. The subsequent transition data show that the agency has reduced its debt by about ¥1 trillion per year on average since it was established. The average interest of interest-bearing debts is less than 2%, implying that the agency effectively manages interest utilizing continuous low-interest circumstances.

As this example shows, the management of interest rate (borrowing rate) is extremely important in infrastructure management. Methods to manage interest including rolling over to a loan with a lower interest rate (refinancing), hedging interest risk by derivatives, and procurement and operation of funds by securitizing future loan fees (monetary claims) from expressway companies to mitigate the risk of interest rate fluctuations. These complex management methods have already become common among the public transport business entities in the US.

6.3.4.4 Risk of Funding Flows and Closing Down Projects: The Case of Local Railways

We see so many local railroad lines being discontinued these days. Among them, in not a few cases, the business entities are forced to give up projects due to difficulties in covering restoration costs after disasters. On these small types of railway lines, the business operators have already cut costs and have small but stable funding flows even in areas with small demand. Small-sized cash circulation reveals its vulnerability when unanticipated expenses occur. The closing of Takachiho Railway in Miyazaki Prefecture is one case, and Minamiaso Railway following the Kumamoto Earthquake of 2016 is also facing similar difficulty.

Takachiho Railway is a 50-km line in Miyazaki Prefecture connecting Nagaoka Station to Takachiho Station. Its predecessor had been one of the specified local lines of the former Japanese National Railways. When JNR was privatized, the railroad facility and operating function were transferred to a third-sector company, Takachiho Railway Co., Ltd. The initial plan projected that it would become profitable in FY1989, 17 years after transferring to the third sector. Unfortunately, the number of users was sluggish and a deficit of around ¥60 million to ¥70 million continued. Half of the loss was compensated by a national subsidy until the fifth year after opening. After that, the line kept using the government-provided transfer-grant fund that was given when it was detached from JNR, and subsidies from Miyazaki Prefecture and municipalities along the line.

However, the flooding of Gokase River due to Typhoon 14 in 2005 washed away two bridges and rails in some sections and destroyed part of an embankment under the rail. The damage to Takachiho Railway was huge. The restoration cost was calculated as ¥400 million for 10 years. That amount of money was difficult to procure for the small local third-sector company even presuming support from the main shareholders, prefecture, and municipalities along the line. The company gave up operating the railway. And the company itself was liquidated in the stockholders' general meeting at the end of the year.

6.4 Infrastructure Services and Business Development

Here we discuss how infrastructure operators expand their business based on their infrastructure services. Especially in the public–private mixed type and private business type, some operators develop the business well by making use of the special characteristics of their business. There are various types, but this section classifies two: (i) expansion of infrastructure services and (ii) user-oriented business development.

The expansion of infrastructure services is where one business entity expands its operation and management services to many other areas of infrastructure. This type of business development is often seen in areas where separation of possession and operation makes operation a unique business, like railways, airports, and ports.

User-oriented business development is where the operation and management entity provides various products or services as well as infrastructure services to frequent customers. Some infrastructure gets many repeat users. The typical example is property development by private railway companies, discussed below.

6.4.1 Development of Infrastructure Services

6.4.1.1 International Development of Infrastructure Operators

Entering infrastructure operation seems to be difficult because the market often has restrictions on entry and withdrawal in addition to requiring unique expertise. Once business experience is acquired, the knowledge can be used in other infrastructure operations. Operations in ports, airports, and water supply have some international universality that allows some operators to contract operation work in domestic and international airports and ports by utilizing their competitiveness based on experience, as we saw in Chapter 3.

This tendency may be increasingly pronounced in the future. More private companies may appear that can handle part or all of the planning, funding, construction, and operation. That is because public–private partnerships/private finance initiatives and concessions that have been developed and spread first in developed countries will become more popular in many other countries. There was the interesting case of the Millau Viaduct in France, seen in Chapter 3, where the contractor mainly established the operation company and contracted from funding to operation as a concession. The construction industry is basically a built-to-order industry and has the characteristic that it must obtain new orders to maintain companies.

On the other hand, the infrastructure operation business can expect long-term and stable profit for decades even though public regulations sometimes prevent high profits. From the perspective of business enterprise management, the combination of businesses with different properties (portfolios) is attractive. Many players will surely participate in the market of international infrastructure operation in the future. Within such a trend, entry from different industries including the construction industry will be also increased.

6.4.1.2 Examples

The case of business expansion to other regions and countries through experience of infrastructure operation can be seen in operators of ports and airports, as written in Chapter 3. Here, the water business and ground transport will be explained as cases in other fields.

Water Business: Veolia Water

Water supply and sewage processing are generally referred to as the water business, and its global market is estimated at nearly €800 billion. While this business area is relatively regarded as the pure public goods type in Japan, privatization is developed in Europe, and one of the leading companies is Veolia Water in France.

The company has about 100,000 employees and has developed business in 43 countries where it operates about 4,700 locations that supply 9.5 billion cubic meters (m^3) of water annually. Moreover, it manages 3,500 public sewage treatment plants and treats 6.7 billion m^3 every year. The supplied population reaches 130 million, the sales account is €30 billion, and the profit is over €1 billion.

The company was established in 1853 by the edict of Napoleon III as the concession company to undertake the water supply business in Lyon City. The experiences in Lyon allowed them to expand the water operation service in other regions: Paris in 1861, and London, Berlin, and Leningrad in the 1900s. They utilized new technology actively, coming up with the world's first ozone treatment facility in 1907 and the world's first nanofiltration treatment instrument in 1999. What enabled them to expand their business to the world is said to be their services that individually and comprehensively correspond to each phase: to provide the necessary instruments for water treatment, to manage design and construction of facilities related to water treatment, and so on. The company has a portfolio in which 70% is public demand and 30% is private demand. They are said to introduce new technology first in the private market and, as a result, cost is reduced through competition. When they introduce that cost-effective technology to public bidding, they can win easily. They seem to have a strategy to maintain long-term and stable profits.

Railway Operation: Overseas Expansion of MTR Corporation

Companies that globally develop railway operations have increased in European countries as the separation of infrastructure and operation of railway projects, concessions, and public–private partnerships/private finance initiatives have expanded. These companies exist in various countries, such as Veolia Transport in France, FirstGroup Plc in the U.K., and Thalys International in Belgium. Additionally, railway operators interested in overseas business have recently appeared in Asia. MTR Corporation is one case. The company was established by the sole investment of the government of Hong Kong, China in 1975 and was converted into a stock company in 2000. They utilize the experience of railway operation and property development in Hong Kong, China and expand their business to the world, such as build–operate–transfer subway operation in Beijing and Shenzhen, a joint venture railway operation in London, and subway operations by concession in Stockholm and Melbourne.

Expressway Operation: Global Development Mainly by European Companies

Europe also has many companies globally developing expressway operations because concession is pervasive. These companies, such as Iridium Concesiones de Infraestructuras, S.A., Cintra, S.A., and Abertis in Spain; Vinci in France; and Atlantia S.p.A. in Italy, contract and take expressway operating work in North America and Central and South America as well as in European countries.

Most road operation companies that develop globally have the construction function within the company or business group, which allows them to deal with various concession contracts.

6.4.2 User-Oriented Business Development

6.4.2.1 Customers and Needs of Infrastructure

Some infrastructure such as urban railways and expressways have numerous users, and some of them are repeat users. The typical repeat customers in rail and road are urban commuters and scheduled trucks. Over a certain volume, these customers have generated many novel business opportunities.

The customer's final goal of using infrastructure is normally something other than the use of infrastructure. These are needs to reach a destination in the case of transportation facilities, and the usage of the facility is only a method to achieve the purpose. That is why traffic demand is sometimes called "derived demand." The concept of derived demand is important. When the user's purpose of movement is comfortable and safe commuting, it implies that it would be possible to develop destinations along the line to attract offices and schools.

In contrast, if many rail users are hoping for a smoother return home, development of residential areas would become realistic. And as "derived demand of derived demand," a station that every train user must come through would have big potential for retail business.

As mentioned, it is a characteristic of the infrastructure business that it can increase business opportunities related to repeat customers, and there have been many examples. Continuous observation of changing customer needs and efforts to respond to them would directly lead to enhancing the satisfaction of the repeat customers, and thereby the next business development.

6.4.2.2 Examples

Tokyu Group

Tokyu Corporation, whose business area is in the southwest Tokyo Metropolitan Area, has formed a corporate group containing over 100 consolidated subsidiaries. Its remarkable growth started from railway construction and operation with residential area development along the lines, and then various services and businesses corresponding to customer needs have been developed as the population around the lines has increased. This can be seen in the expansion process along the Den-en-toshi Line.

The Tōkyū Den-en-toshi Line, released with the Tama Garden City Plan in the 1950s, was constructed as one of the main commuting lines in the Tokyo Metropolitan Area. The first section was its western part, Mizonokuchi–Tsukushino, constructed in the 1960s. The directly operated Shintamagawa Line and, with Teito Rapid Transit Authority, the Hanzōmon Line started in the 1970s. The land readjustment project planned as Tōkyū Tama Den-en-toshi was in an area of about 3,200 hectares. The population was about 50,000 at the beginning of development and is currently 500,000.

Tokyu Corporation prepared to take advantage of the business opportunities from the population growth along the rail lines by establishing new subsidiaries from the 1950s. Tokyu Land Corporation was established for land development and Toyoko Kogyo (currently Tokyu Store Chain Co. Ltd.) was set up in front of stations operating retail stores and supermarkets. In the 1970s, Tokyu Area Service (currently Tokyu Livable, Inc.) was set up for dealing with relocation demand along the line. In the 1980s, Tama-plaza Tokyu SC, suburb style shopping centers, were opened. Additionally, Tokyu Cable TV started services mainly for the residents living in the area along the train lines. In addition, responding to the high demand for fitness, the franchised fitness club Tokyu Sports Oasis was established and developed. In the

1990s, internet connection services using television cable started, and in the 2000s, Tokyu E-Life Design, which treats elderly homes and Tokyu Wellness, which deals with elderly housing with nursing services, were opened. Tokyu Power Supply, established in 2015, responded to the liberalization of electric supply and started to supply the areas along the line. In this way, the railway company has developed its business properly corresponding to the population increase in the Tokyo Metropolitan Area, city planning, city maturity, and the emergence of new customer needs.

Suica Business in East Japan Railway Company

Individual JR companies have not conducted regional development corresponding to railway construction—unlike private railway companies such as Tokyu Corporation—because their parent organization, Japanese National Railways (JNR), was regulated to specialize in the railway business. However, they have a huge number of customers mainly due to commuting in urban areas. For example, the number of users of the East Japan Railway Company, having 1,700 stations, reaches 16 million per day. It is well known that with such a massive customer base, there has been rapid growth of the business of building, such as station buildings, as well as the provision of life services based on Suica (a prepaid e-money card for transport and shopping).

The terminal station building project of the East Japan Railway Company, known for names such as Lumine and Atré, has been growing chiefly in the Tokyo Metropolitan Area. This project involves 19 companies managing 160 buildings. The gross income from these buildings was more than ¥1 trillion in fiscal year 2015.

Suica, the business-card-sized card embedded with an IC chip, allows automatic payment for transport fares, including fare adjustment by communicating with ticket gates via radio waves. Research and development began in the mid-1980s after the privatization of Japanese National Railways, and it took 16 years until the implementation in 2001. Suica is proliferating, such that the number of cards issued reached 59 million in March 2016. It is compatible with other railways in the Tokyo Metropolitan Area and 10 transport cards used in the Osaka area, Nagoya area, and so on.

The effects of the introduction of Suica are the direct improvement of users' convenience, cost reduction of ticket service, and, as a result, income gain in short-distance sections. There is an extremely big advantage for funding in that the companies can get a huge amount of cash in advance without interest because Suica is a prepaid card. Moreover, the large-scale spread of IC cards generated a business area that can be called the electric money business. For example, 340,000 stores accept Suica for payment and most of them are outside stations. Electric money is used more than 5 million times per day. Besides, Suica is also used for payments in online shopping, taxis, lockers, and vending machines, and generates many business opportunities including fees. The individual records of purchase and movement are traced through Suica because each Suica card has a unique number. The value of these records will be increase in the future, as they are extremely useful “big data” for marketing.

6.5 Disaster Prevention and Recovery

6.5.1 Natural Disasters in Japan

Disaster prevention is an unavoidable issue in infrastructure projects. Japan has many natural disasters and this tendency has been seen recently. It is especially important to prepare for earthquakes, tsunamis, volcanic eruptions, typhoons, and torrential rain.

The Japan Meteorological Agency says that Japan and its surrounding area experience earthquakes of magnitude 6 and higher more than 20 times a year. This area occupies over 10% of the world. More problematic is that Japan has no region in which earthquakes do not happen.

Japan is also one of the countries with volcanos, having 110 volcanos of which 47 are active and must be continuously observed. In recent years, many people were killed or went missing in the eruption of Mt. Unzen (Nagasaki Prefecture) in 1991 and Mt. Ontake (Nagano and Gifu Prefectures) in 2014.

Typhoons are born in the northwest Pacific Ocean. They tend to pass through Japan as they move up to the north along with the edge of the subtropical ridge. There are three typhoons per year on average—but sometimes over 10—that cause severe damage in many regions.

Torrential rain sometimes causes severe damage too. Rainfall over 50 mm/hour is very hard rain and over 80 mm/hour is violent rain. The AMeDAS observations (data from 1,000 areas in Japan) suggest that the former is observed 200 times and the latter 10 to 30 times in a year, and the number tends to increase.

The infrastructure business entities in Japan are required to operate steadily and respond properly in emergency periods under these natural conditions.

6.5.2 Basic Act on Disaster Control Measures and Infrastructure

There are several aspects of the relationship between natural disasters and infrastructure.

First, infrastructure itself plays a role in protecting the land and people. That is, it is most important in national land resilience and conservation. The typical facilities for national land conservation include levees, retarding basins, seawalls, and erosion control facilities. These can be called infrastructure for disaster prevention, and most are the pure public goods type. Unlike individual facility construction, there are efforts to minimize socioeconomic damage during emergencies, for example, by constructing an alternative road in case the main route becomes unavailable. The effect of such alternative routes is sometimes generally called enhancement of redundancy (alternativity or flexibility).

Second, infrastructure managers are required to take preparations and measures for disasters at their facilities. Even when natural disasters happen, infrastructure must function as much as possible, minimize the damage for the community, and support its activities. Thus, repeated work is necessary such as snow removal in heavy snow areas and reinforcing; seismic retrofitting is a good example. Moreover, usage restriction is needed when further service will increase damage. Access limitation to viaducts buffeted by strong winds is one such case.

In disaster prevention, for restoration and renewal against natural disasters like those above, it is essential to collaborate with other stakeholders in the community instead of the infrastructure manager acting alone. The government's guidance on this topic is summarized in the Basic Act on Disaster Control Measures and some related acts, so infrastructure managers should understand that act well.

6.5.2.1 Basic Act on Disaster Control Measures

The Basic Act on Disaster Control Measures is the fundamental law on disaster administration in Japan, a country that has encountered many severe disasters. It was enacted in 1961, prompted by the huge damage due to the Isewan Typhoon in 1959. Before that, Japan is said to have had 150 to 200 specialized laws on disaster measures, and their relationships were not clear.

The contents of the law were greatly improved based on the experience of the Great Hanshin Earthquake and Great East Japan Earthquake. Currently the structure is as follows.

General Rules

Chapter 1, General Rules, shows the related organizations, their obligations, and the designated administrative organizations. The rules state that the central ministries and designated public organizations like expressway companies and airport companies (including major infrastructure enterprises) must fulfill the responsibilities in their business fields during emergencies.

The act stipulates that the obligations of the designated public organizations are considering an operation disaster plan, executing it, and cooperating with the central and local governments to make for smooth operation and execution of the disaster plan.

Disaster Prevention Organization

The Basic Act on Disaster Control Measures stipulates a hierarchical organizational system dealing with disasters for both normal and emergency periods.

The central government is to establish a Central Disaster Management Council in the Cabinet Office, headed by the Prime Minister. The Council is to plan and show a basic national policy on disasters. Each prefecture's government is to set up a Local Disaster Management Council whose chairperson is prefectural. Cities are to establish a City Disaster Management Council led by the city governors, and they draw up the disaster prevention plan of each region.

During severe emergencies, the related prefecture's governor as well as the city mayor may establish a disaster countermeasures office. The leader of the local government, the governor, or the mayor will become its chairperson. The Prime Minister can set up a Central Disaster Management Council led by Minister of State. When an extraordinary and severe emergency disaster affecting more than one municipality happens, the Prime Minister can establish an Emergency Disaster Management Council and be its head.

The designated administrative organizations and the designated public organizations including infrastructure enterprises are required to properly prepare, following the national disaster prevention concept, during normal (non-emergency) times. During emergencies, they are to help minimize community damage and rapidly restore and reconstruct following the direction of the Central Disaster Management Council.

Disaster Prevention Planning

The Central Disaster Management Council draws up and publishes the basic plan for disaster prevention as the national guidance. It also shows policies for each disaster type on disaster prevention, response, restoration, and reconstruction.

These include sea disasters, aviation disasters, railway disasters, traffic disasters, nuclear disasters, and forest disasters as well as natural disasters like earthquakes or tsunamis. It can be said that disasters related to infrastructure have a big social influence.

Based on this basic plan for disaster prevention, local governments formulate regional disaster prevention plans and designated public organizations such as private infrastructure corporations draw up disaster prevention operation plans. These plans are to be reviewed regularly.

Promotion of Disaster Prevention Measures

The role and authority of each responsible entity are determined at each step: disaster prevention, response, and reconstruction.

Disaster prevention consists of designating a person responsible for disaster prevention, organizing a system for disaster prevention, education on disaster prevention, required emergency training, required storage of the necessary goods and materials for disaster prevention, required measures to gain cooperation with goods providers at times of emergency, and designation of shelters.

Disaster response measures are warning announcements and notifications, recommendations and instructions for evacuation, temporary measures like fire extinguishment and levee protection, and rescue operations including evacuation and other protection for affected people. Within these measures, those related to infrastructure are traffic restriction and ensuring emergency transport. Traffic restriction is determined by the Minister of Land, Infrastructure, Transport, and Tourism (national roads), the Minister of Agriculture, Forestry, and Fisheries (farm roads), and the Prefecture Public Safety Commission (local roads, etc.). They also inform road managers of designated areas and directs the restriction.

Those who are responsible for disaster reconstruction are specified by the Act: the heads of the designated administrative organization, local administrative organizations, and local municipalities.

Financial Measures

Business entities basically pay for the cost of disaster prevention themselves. But as an exception for serious disasters, there is special financial aid from the central government to local governments.

Infrastructure restoration has several budget measures (e.g., river disaster restoration projects) based on the National Government Defrayment Act for Reconstruction of Disaster Stricken Public Facilities.

When the disaster scale is extremely large and the affected areas and victims strongly need aid and financial support, the central government officially specifies that disaster as a Designated Disaster of Extreme Severity. This designation is based on the Act on Special Financial Support to Deal with the Designated Disaster of Extreme Severity, and it increases the subsidy from the national government for reconstruction. The targets are damage of (i) public facilities, (ii) farmland, and (iii) small and medium-sized enterprises. The first two are related to infrastructure. The main purpose of this system is the reduction of financial liability for local governments, and the target infrastructure for the subsidy is chiefly the pure public goods type.

There are two types of designated disasters of extreme severity. The cases where the damage suffered by multiple municipalities exceeds the designated standard are to be designated by the criteria for disasters of extreme severity (hongeki in Japanese). The other cases that exceed the criteria for each municipality are to be designated by the local criteria for disasters of extreme severity (kyokugeki). An example of kyokugeki is localized downpours.

Disaster Emergency
The prime minister can proclaim a disaster emergency for extremely big disasters. At this time, Extreme Disaster Management Headquarters are established. Based on their decision, emergency decrees on restriction like supply of the necessary goods, deferred debt payment of victims, and receipt of aid from abroad can be enacted.

6.5.2.2 Disaster Measure Funding of Private Companies

As mentioned above, when disaster causes damage to pure public goods type infrastructure, National Government Defrayment for Reconstruction of Disaster is applied. The designation of extremely severe disaster allows an increased amount of subsidy. This is significant to compensate for the problem that pure public goods type infrastructure uses public accounting and is not allowed to accumulate long-term maintenance and repair funds.

In contrast, the public–private mixed type and private business type are complicated due to the application of individual related acts. In the case of the railway business, based on the Act on Improvement of Railroads and Rail Tracks and its enforcement ordinance, the national and local governments can support disaster restoration cost through the Japan Railway Construction, Transport, and Technology Agency. However, shinkansen, main railways, and urban railways are not included in the scope. Further, the application conditions are strict. For example, reconstruction cost must be over 10% of the transport income of the line, or the damaged railway route revenue must have been in deficit at least successive three years before the disaster happened. Accordingly, the reconstruction of the Tōhoku Shinkansen after the Great East Japan Earthquake was totally self-paid by the East Japan Railway Company. On the other hand, the restoration cost of the expressway after that earthquake was funded by the public Japan Expressway Holding and Debt Repayment Agency. The agency got a subsidy from the national government and utilized it in offering zero-interest loans to expressway companies.

Like this, for the public–private mixed type and private business type, public subsidization for reconstruction following disasters is limited, so they must properly prepare of funding themselves, including utilizing insurance.

6.5.3 Examples

6.5.3.1 Recovery of Kōbe Port from Great Hanshin Earthquake

The Great Hanshin Earthquake (magnitude 7.3), whose epicenter was on the northern part of Awaji Island, struck on 17 January 1995. It caused broad damage mainly in the Kinki region of Japan, leaving 6,400 people dead or missing and 44,000 people with serious injuries. The damage was severe in Kōbe near the epicenter, and infrastructure such as roads, ports, railways, water, and sewage was destroyed. Below, we describe the damage and restoration of Kōbe Port, as well as the resulting influences, as the representative infrastructure of the city.

Most of the 239 big berths of Kōbe Port, of which 186 were publicly owned, and the 23-kilometer-long wharf, were broken. Many sheds, open storage yards, cargo operation machines, and private warehouses became unusable. Also, all 21 container terminals handling external trade were unavailable after the earthquake. With the access roads broken, land transportation to the port also became impossible.

The Japanese government, considering the serious situation, enacted the Act for Extraordinary Expenditures and Assistance to Cope with the Hanshin Earthquake. The new Act enabled the central and local government to make restoration faster in the following ways. The central government supported the wharf restoration of Kōbe Port Terminal Corporation, which was not eligible for The Law Concerning Special Fiscal Aid for Coping with Disasters. They also subsidized the Hanshin Expressway Public Company and the stricken municipalities that needed to repair the railways. Funds were used from local governments' general accounts for the restoration projects of local public enterprises.

Infrastructure was intensively restored, and the resumption of Kōbe Ōhashi, Rokkō Ōhashi, Hanshin Expressway, and access roads like Route 43 was mainly realized within 1996, 1 year after the disaster. The container berths had only provisional service for the first several months while restoration continued. And 25 berths, the same number as just before the earthquake happened, were in full service in April 1997. The number of available berths recovered to the pre-earthquake level by the end of March 1997. That is, the hardware restoration was mainly finished in 2 years.

However, Kōbe Port's rank for container transactions, the third in the world in 1980, dropped to 23rd in 1995 and hovered at a low level of 56th in 2015. The container transactions at Hong Kong Port were 1,465,000 TEU in 1980, almost the same as Kōbe Port, but exceeded 20 million TEU in the 2000s, growing by over 10 times in 10 years. Shanghai Port, overtaking Hong Kong Port, was at 35 million TEU in 2015. The development of global containerization made the transactions in large Asian ports 10 times larger between the 1980s and 1990s.

Kōbe Port has fairly increased the transactions with the restoration progress in the background, and container cargo transactions in 2015 were 2,556,000 TEU, 1.7 times larger than before the earthquake. However, this is around 10% compared with the activity of the world's leading ports. Kōbe Port unfortunately has lost the competition of global containerization because of the earthquake damage.

6.5.3.2 Damage and Restoration of Infrastructure from Great East Japan Earthquake

At 2:46 p.m. on 11 March 2011, a big earthquake of magnitude 9.0 and seismic intensity 7 (the strongest ever recorded in Japan) struck eastern Japan. The epicenter was off the Sanriku Coast. It was an unprecedented disaster, with 15,894 dead, 2,550 missing, and more than 400,000 buildings and houses totally or partly destroyed. Roads and railways were severely damaged.

The Cabinet Office estimated that the damage of lifelines (water, gas, electrical power, and communication and broadcasting facilities) amounted to ¥1.3 trillion, and that of infrastructure (rivers, roads, ports, sewage, airports, etc.) to ¥2.2 trillion. As the role of infrastructure is crucial in the process of rescue, emergency restoration, and full restoration, quick restoration was done for each.

For the road network, the state of damage in the coastal area was unknown right after the earthquake. On the other hand, the damage of the inland sections of Tōhoku Expressway, which runs from south to north in the Tōhoku region, and Route 4, was relatively small. Thus, a three-step plan was considered: (i) first, the longitudinal axis of the Tōhoku Expressway and Route 4 were to be secured, (ii) next, 16 routes to relieve the stricken area in the shape of the "teeth of a comb" running east to west from the vertical axis were secured, and (iii) finally, Route 45 running south to north in the coastal area was to be secured. This was called "teeth-of-a-comb tactics."

From the next morning, elimination of road obstacles was started to secure the roads that allow emergency vehicles to reach the destination. There was no taking ordinary vehicles into consideration. The final goal, the elimination of road obstacles on Route 45, was almost achieved in 1 week.

For the railway network, the reconstruction of the main railway quickly proceeded so that the JR Tōhoku Line fully recovered on 21 April, 40 days after the disaster, and the Tōhoku Shinkansen was recovered on 29 April. However, the damage of the local lines running in the Sanriku coastal area was big, and as mentioned in the next section, the reconstruction projects are still being implemented even today.

6.5.3.3 Reconstruction of Sanriku Railways

The railway network along the Sanriku Coast can be divided into five sections: from north, Sanriku Railway Kita-Rias Line (Kuji–Miyako), JR Yamada Line (Miyako–Kamaishi), Sanriku Railway Minami-Rias Line (Kamaishi–Sakari), JR Ōfunato Line (Sakari–Kesen Numa), and JR Kesen Numa Line (Kesen Numa–Yanaizu). They were severely damaged by both the Great East Japan Earthquake and the tsunami that occurred immediately afterward.

For reconstruction of the Sanriku Railways, ¥9.2 billion came from the disaster restoration subsidy scheme in the Act on Improvement of Railroads and Rail Tracks. The expenses were paid entirely by public funds. Originally, half of the restoration cost was supposed to be paid by the railway companies and the remaining half to be paid equally by the national government and related municipalities. But in the case of Sanriku Railways, the municipalities restored and later owned the stricken facilities. And they and the national government each paid for half of the cost. Sanriku Railways could be restored without self-payment by placing their facilities under the possession of the municipalities. Sanriku Railways had already been in a difficult business situation. The railway, taking over the deficit of the local rail line from the former Japanese National Railways, had had average sales of ¥400 million a year and a loss of over ¥100 million a year. The national government secured this subsidy cost in an extra budget in FY2011. Both the Kita–Rias and Minami–Rias Lines resumed operation in April 2014.

The East Japan Railway Company intended to reestablish transportation between Ōfunato and Kesen Numa Line by operating bus rapid transit instead of the destroyed railway. However, the Yamada line was recovered and relegated to Sanriku Railways in March 2019. Sanriku Railways operates the combined line of 163 km from Kuzi to Sakari as the new Rias Line.

6.5.3.4 Infrastructure Reconstruction from Kinu River Flood in 2015

In September 2015, heavy rain was recorded due to Typhoon 18. In Ibaraki Prefecture the 24-hour rainfall from 10 to 11 September was 300 to 600 mm, the largest ever recorded downpour.

Kinu River, the tributary of Tone River, recorded a 4,000 cubic meter/second flow, which was the biggest flow ever recorded at Mitsukaidō. The river overflowed at seven points and broke down a 200-meter levee at Jōsō City, Misaka Machi. Many houses were destroyed by flooding around the washed-out points. The damage of this flood was very big: 2 dead and over 4,000 houses fully or partly destroyed. An evacuation order was made to 11,230 households with 31,398 people, and an evacuation advisory went to 990 households with 2,775 people.

As disaster measures, several municipalities in Ibaraki Prefecture established emergency response headquarters during the period from the night on 9 September to the daytime on 10 September. Jōsō City, one of the hardest-hit municipalities, appealed for the disaster dispatch of the Japan Self-Defense Forces early in the morning on 10 September.

This disaster was designated as an extremely severe disaster (hongeki, kyokugeki) because the extent of damage exceeded the criteria. The destroyed levee points were repaired by the national government's River Disaster Restoration Project and Special Emergency Project for River Extremely Severe Disaster Measures. After that, comprehensive restoration policies have progressed under the collaboration of the national government and local municipalities. For example, the Kinu River Emergency Countermeasure Project is a combined policy that contains hardware measures, such as the improvement project in the downstream areas of Kinu River through special emergency projects for the control of severe river disasters by the national government and tributary improvement by Ibaraki Prefecture, and software measures like emergency evacuation training.

Many private infrastructure enterprises were also stricken. In particular, Kantō Railway, operating two lines in Ibaraki Prefecture, became unable to operate. All the lines were stopped because the rail of the Jōsō Line from Toride to Shimodate was partially submerged.

But some sections were recovered 1 week after the disaster and all lines were back in 1 month. These were carried out by the company on its own.

6.6 Replacement and Elimination

6.6.1 Facility Life Span

Some of the roads or bridges constructed in ancient Rome are still utilized in the 21st century. The sewage system in Paris and the subway in London, with maintenance and repair, have been used for about 150 years since construction. While such infrastructure is used for a very long period, we see some railways discontinued, and some airports abandoned. In this way, infrastructure life span varies.

From the viewpoint of accounting, structures' longevity is set as durable years of depreciating assets. For example, in accounting, the life span of viaducts is 30 years. The other way of setting durable years is to determine it from the physical point of view at the design phase. Honshū–Shikoku Bridge was set as 120 years. However, these set years rarely match the actual service life of infrastructure.

It is said that there are three viewpoints by which the life span of infrastructure is judged: physical, functional, and economic. As the period from start to finish of service is called the life span, we have physical life span, functional life span, and economic life span corresponding to each viewpoint.

Physical life span is the period until structures are deteriorated and unusable. Concrete and steel are vulnerable to water, and if salt is present, deterioration progresses more quickly. Railway bridges and road bridges deteriorate by fatigue due to repeated loads. The moment that the structure is deteriorated and is determined to be unusable because of the danger of falling or collapsing is the end of the physical life span of that infrastructure. Of course, the physical life span can be extended by proper maintenance and repair.

Functional life span means that regardless of the physical state of the infrastructure, the value of it existing is lost due to changes in the environment or in users' needs and social needs. Examples include the width of existing roads becoming insufficient due to larger vehicles being made, the storage function of dams decreasing due to sand accumulating, and existing buildings no longer meeting requirements due to stricter seismic design requirements.

Economic life span refers to the maintenance cost of structures becoming too high, making management financially difficult. The economic life span of the structure ends when the total costs during the remaining service period, including repair cost due to ageing and reinforcement, are so large that replacing it with a newly constructed one is considered economically reasonable.

Recently, the maintenance and repair costs of infrastructure as a whole have been expanding and measures to prolong life spans are actively discussed. This is largely related to extension of physical life span. But that alone is not enough; we must consider functional and economic life spans and always bear in mind use conversion and disposal at the proper time.

From these perspectives, regarding infrastructure that has reached the end of its life span, the smart use cases in consideration of the needs of the time are discussed below. These examples show that while infrastructure is used for the long term in general, in reality drastic changes in the socioeconomic environment continue to call into question the raison d'être of the existing infrastructure, and some aspects of the usage change sooner than we imagine.

6.6.2 Use Conversion and Idle Asset Utilization

6.6.2.1 Railway and its Site

Conversion from Cargo to Passengers: Tokyo Mega Loop, Shōnan–Shinjuku Line, Ueno–Tokyo Line

The East Japan Railway Company collectively refers to the four lines within about 20 to 30 km from Tokyo Station as "the Tokyo Mega Loop." They are the Musashino Line, Keiyo Line, Nambu Line, and Yokohama Line (Figure 6.10). On these lines, JR tries longer distance direct operation and other new services to enhance the convenience of passenger transport. These four lines were originally planned and constructed mainly for cargo transport.

The Yokohama Line was originally constructed by Yokohama Railway (a private railway) in 1908 to connect Hachioji, a production area of silk, to the export base of Yokohama Port. Later it was connected at Hachioji Station with the Chūō Main Line and Hachikō Line, and silk from the Kōshin region was also transported.

The Nambu Line, constructed in response to the increasing construction demand in central Tokyo in those days, started as the Tamagawa–Jari railway between Kawasaki and Omaru in 1927, taking gravel from the Tama River to Tokyo. After that, the Nambu Line was connected with the Ome Line to transport limestone, a material used in

Figure 6.10: "Tokyo Mega Loop" Rail Network

cement. Then, as many facilities came to be located along the line, the rail was used for military transportation. After World War II, it came to have a logistical use for the big electronics companies that developed in the surrounding area.

The Musashino Line was planned as a bypass line of the Yamanote freight line, which connected the Tōkaidō Main Line and Tōhoku Main Line before World War II. The construction started after the war, and it was opened in stages beginning in the 1970s. Currently, it has three terminal freight stations, Kajigaya, Niiza, and Koshigaya, and the line is working as a logistics route as well as for commuting.

The former Japanese National Railways planned the Keiyo Line as a freight line conveying oil from Tokyo Port to the Keiyo industrial area. They first opened a freight section, Soga Station to Chiba-Terminal Station in 1975. Currently, it is the commuting line directly connecting to Tokyo Station and is heavily used as the access line to Tokyo Disney Resort. But even now, sections like Soga Station to Nishi-Funabashi Station are used for freight transportation.

All four lines have grown to function increasingly as commuter lines because the population growth in the Tokyo Metropolitan Area and urban expansion in the postwar period remarkably increased the commuting demand in a broad area. Plus, the logistics demand for the lines has stagnated due to several factors such as the development of a nationwide road network, a shift to trucks as a means of transport, and the decline of specific logistics demands (gravel, silk, etc.). Recently, the East Japan Railway Company has introduced new rapid trains and vehicles and promoted measures to ease passenger congestion. This case is an example of the functional life span of infrastructure for one use (railways for freight transport) ending and usage being converted (in this case, to commuter transport), although the infrastructure has not reached the end of its physical life span.

Additionally, the Shōnan–Shinjuku Line and Ueno–Tokyo Line are other cases of utilizing existing freight lines as new commuting lines. Both are the developments of new lines to deal with the broad commuter demand around Tokyo, and to handle the increased need to improve the connectivity between the northern and southern parts of the Tokyo Metropolitan Area.

The Shōnan–Shinjuku Line, started in 2001, is the direct operation of the Tōhoku Main Line (Utsunomiya Line), Yokosuka Line, Takasaki Line, and Tōkaidō Line, using the railway tracks of the Yamanote Freight Line as a connecting part. The Ueno–Tokyo Line, started in 2015, directly operates several lines: Tōhoku Main Line (Utsunomiya Line), Takasaki Line, Jōban Line, and Tōkaidō Main Line. Existing facilities such as storage tracks and lead tracks between Tokyo Station and Ueno Station (called the Tokyo–Ueno forwarding line) are utilized, and as a connecting part, new rail tracks like the elevated line between Kanda Station and Tokyo Station were constructed.

Application of Yard and Station Sites: Shinagawa Rail Yard, Former Shiodome Station

Because the connecting line between Tokyo and Ueno was constructed, the trains of the Tōkaidō Line, originally using the Shinagawa depot located south of Tokyo Station, were able to utilize the Oku rail yard north of Tokyo Station. The Shinagawa depot, an area about 15 hectares wide on the north side of Shinagawa Station in the city center, was to be empty and was anticipated as a precious site for commercial and business development. For this reason, the site was designated a National Strategic Special Zone by the national government and a plan was established for huge urban redevelopment and construction of a new station. Similar with the case of the Tokyo Mega Loop, this can be seen as a good example of infrastructure use conversion for new social needs, dealing with the situation that the existing physical structure has reached the end of its functional life span.

As one of the oldest railway stations in Japan, Shiodome Station of the former Japanese National Railways was the successor of Shimbashi Station in Japan's first railway line, Shimbashi–Yokohama, starting in 1872. After the opening of Tokyo Station (1914), the old Shimbashi Station changed its function from passenger station to freight station. It was the first station for container trains in the postwar period. However, the station was closed in 1986 because of the shift from rail transport to truck transport.

The site was sold to repay the long-term debt of the former Japanese National Railways. Because it is close to central Tokyo, the site has been redeveloped as Shiodome Sio-Site with many office towers. This is also a representative reuse case for responding to the functional life span of freight railways and social needs.

Usage of Rail Track Sites

When railway life span ends and after removing the rail, ideas are needed for utilizing linear track sites not suitable for ordinary land use.

There are many cases using track sites as bus lanes to maintain their transportation function in the community. For example, it is well known that in Kitakyūshū City, after the Nishi-Nippon Railroad Tobata Line was discontinued, the rail track site was changed to a bus lane. (Later, it was widened and became an ordinary road.) Recently, some sections of the East Japan Railway Company Ōfunato Line from Kesen Numa to Ōfunatoshi, which had been damaged by the Great East Japan Earthquake, were restored not as railways but as bus rapid transit lanes.

When a train line that has been travelling at ground level is moved underground or is elevated, a section of long and difficult-to-use land is left on the ground. Many railways in the Tokyo Metropolitan Area have been turned into subways or elevated railroads. The reasons for this are the economic and environmental losses caused by the ground-level crossings of the rail and the roads interrupting road traffic, and the increase of the needs for urban redevelopment or extension of direct operation with other suburban lines. In a recent case, the Tokyu Corporation Tōyoko Line, the sections of Yokohama Station to Higashihakuraku Station and Shibuya Station to Daikanyama Station were taken underground, achieving a mutual extension operation with the Minato Mirai Line and Tokyo Metro Fukutoshin Line. Meanwhile, the track sites in Yokohama and Shibuya became vacant. The site around Yokohama Station has become a 1.4-kilometer greenway first proposed by discussion with citizens in order to generate reuse ideas for Yokohama City. The part of the site from Daikanyama Station to Shibuya Station became a shopping area.

On the other hand, in some railways it takes time to convert the usage of facilities whose life span has mostly ended. One case is the Nanpō Freight Line, which was constructed to improve the logistics capacity in the Nagoya area. This line was a freight branch line of about 26 km of the Tōkaidō Main Line, connecting Nagoya Freight Terminal Station to Kasadera Station and Ōbu Station, and about 90% was constructed by 1975. However, it was stopped before completion. There were many reasons: demand for railway freight unexpectedly decreased, some members of the local public were concerned about the expected noise and vibration and litigated JNR, and JNR itself could not afford to think about it because of the contentious discussion about privatization. While part of the construction site was reused as parking lots and shopping centers, even now a lot of the elevated structures remain unused.

6.6.2.2 Expressways

The Case in the Republic of Korea: Expressway Channelization in Cheonggyecheon

The trend of land transportation in the world since the latter half of the 20th century was generally the progress of motorization. For this reason, there has been little need for disposal or use conversion of expressways, but a small number of characteristic cases exist.

One case was the removal of Cheonggye Freeway, an elevated highway in Seoul, Republic of Korea, and the restoration of the Cheonggye River. The river called Cheonggyecheon, flowing in the center of Seoul City, was covered with concrete, on which the Cheonggye Freeway elevated highway was constructed and opened in 1976. It was one of the important main roads; the traffic volume was 65,000 vehicles per day on the arterial road and 102,000 vehicles per day on the elevated highway, with a total of 167,000 vehicles per day. The deterioration of the structures became so critical in the 2000s that the repair cost was KRW100 billion (nearly $90 million) in 3 years. In 2002, the city got a new mayor, who decided to remove the elevated highway and launch a restoration project. The building cost was KRW360 billion (over $320 million), the construction period was 3 years and 3 months, and it was completed in October 2005. Cheonggyecheon became open water again and paths were installed along the riverside. To deal with expected traffic congestion, the city authorities introduced a bus management system and bus rapid transport. The proportion of bus use in public transportation grew.

The Case in the US: The Big Dig in Boston, Etc.

The Central Artery, the elevated main road with six lanes running through the center of Boston, supported traffic of 200,000 vehicles per day in the 1980s (60% was transit traffic), while it had been estimated at 75,000 when planned in 1959. The road was struggling with big problems of chronic congestion, high accident rate, deteriorating environment, and division between the city center and the riverfront area by the elevated highways. The sum of these losses was estimated at $500 million per year (¥113 billion at the current rate). The big project to drastically improve the situation was that a new expressway with eight or ten lanes was to be installed underground to replace 2.5 km, the part of the elevated expressway. An open space was planned to be constructed on the premises where the elevated expressway had been. It was named the Big Dig because of the type of construction.

The environmental assessment started in 1982, and the project was authorized by the Federal Highway Administration. Construction started in 1991 and was mostly completed in 2006. The construction cost was $14.6 billion. That was three times larger than the expectation, and the federal government paid for half. The now open space above the undergrounded expressway is a park that many people use for recreation along the Charles River.

Relocating elevated roads underground or removing them has happened since the 1960s in the US, though these cases are still very rare. In Portland, once there was an elevated road along the river running through the city center. That road was removed to resolve the division between the city and the river and to improve the environment, and a waterfront park was constructed on the site. In San Francisco, the Embarcadero Freeway, an elevated road destroyed by the Northridge earthquake in 1987, was not reconstructed but removed, and the area was redeveloped. That road had also divided the waterfront and the city area. The removal was determined by the city after 2 years' discussion. Alaskan Way, an elevated highway in Seattle, was also moved underground after the Nisqually Earthquake damaged it in 2001. Light rail transit was introduced on the ground to create a good urban environment.

Europe: Taking National Roads Underground and Urban Renovation in Düsseldorf and Others

Europe has several cases of revitalizing waterside spaces in cities by taking urban main roads underground to create a good urban environment.

One case is in Düsseldorf, Germany. Two km of federal roads along the Rhine were taken underground and a promenade with a maximum width of 40 m was constructed on the ground. Discussion on this project started in 1979, construction began in 1989 and completed in 1993.

In Paris, the expressway built along the Seine River in the 1960s was reformed as a street for pedestrians and bicycles in 2012 and 2013. The roads dedicated to cars were reconstructed partially underground, hidden from pedestrians' sight.

6.6.2.3 Others

Water Purification Plants: Shinjuku Subcenter of Tokyo

Water purification plants, which purify and disinfect water, are located on relatively broad dedicated sites. They are often installed near urban areas. Recently, some of these plants have moved to suburbs because land demand in cities is growing and water purification plants themselves need more space.

The most well-known case would be the transfer of the Yodobashi Water Purification Plant, once in Shinjuku Ward of Tokyo, and the development of Shinjuku Subcenter using the site. The Yodobashi Water Purification Plant was installed in 1898 on a 34-hectare site to solve health problems including a cholera epidemic in Tokyo. Raw water was drawn from the Tamagawa water supply system, purified, and supplied to locations in central Tokyo such as Shinjuku Ward, Chiyoda Ward, Chūō Ward, and Minato Ward. As Tokyo became more dense, its transfer to the suburbs had been discussed. In 1960, the Higashimurayama Water Purification Plant was completed, and the Yodobashi Water Purification Plant gradually ceased its functions until 1965 and was demolished. Shinjuku was one of the fastest growing districts in Tokyo. The broad premises where the Yodobashi Water Purification Plant had been was very precious for urban redevelopment. Government officials established what was called the Shinjuku Subcenter Plan, in which many skyscrapers and city parks were to be built. The plan was executed promptly, and this area currently has many office towers including the Tokyo Metropolitan Government Building.

There are many cases in which urbanization requires high-density land use in the city center and, as a result, old water purification plants move to suburbs and the remaining sites are redeveloped. Recently, the Yamanouchi Water Purification Plant in Kyoto; the Tokorozawa Water Purification Center in Tokorozawa, Saitama; and the Ikuta Water Purification Plant in Kawasaki have moved to the suburbs and the sites are being reused.

Pier Site: Minato Mirai 21, Port Island

Yokohama Port was opened in 1858 at the end of the Edo era. It was mainly used to export silk. During the first half of the 20th century, the port became the shipping terminal for the iron, shipbuilding, automobile, electric machinery, and military industries located around Yokohama. After World War II, the port had been equipped with the facilities to catch up with the global containerization in marine freight and worked as one of the biggest distribution ports in the Tokyo area. Today it is also known as a port of call for large cruise ships.

However, it began to be pointed out in Yokohama City around the period of high economic growth that there were negative effects of the port facilities because they were preventing smooth traffic between the two main areas in Yokohama City: Kannai and Isezakichō. At that time, development plans were being considered for the area around the port and the district as well as around the former Japanese National Railways Yokohama Station, and the city's population had increased and was expected to increase more in the future. Thus, the necessity for comprehensive urban development was broadly recognized. Accordingly, in 1965, the comprehensive redevelopment plan of the current Minato Mirai district, which covers both Yokohama Station and Isezakichō, was planned and made public by the municipality as one of the six major projects in Yokohama City.

The concept of the plan was that the districts including Mitsubishi Heavy Industries, Ltd. Yokohama Dock, Japanese National Railways Higashiyokohama Station and its yard, Takashima Berth, and Shinminato Berth, were to be renovated to create an integrated urban area with a business center, shopping centers, port parks, and waterfront space. The planned area was 186 hectares, the expected employed population was 190,000, and the expected residential population was 10,000. The plan was implemented beginning in 1983, and more than 1,800 offices have been established, the employed population is over 100,000, and the estimated number of visitors to the district exceeds 80 million in a year. In this way, Yokohama Port itself has maintained and increased the port function while creating a major urban area by reviewing the functional layouts.

Kōbe Port, not having a broad area behind it, has achieved high-level urban functioning by constructing an artificial island. This port had been developed as a hub port in the Kinki region since ancient times and was opened as a global trade port in 1868. Later, as the Hanshin Industrial Zone had been developed, the port was extended with Japan's first container terminal installed in 1967, and Kōbe Port boasted the most container transactions in the world in the 1970s. At the same time, the population in Kōbe City and neighboring areas had remarkably increased due to urbanization, and room for developing urban functions was required. Accordingly, a port island plan was drawn up in which two artificial islands were to be constructed off Kōbe Port in order to expand and advance port and urban functions. This plan was driven forward in the first period (1966 to 1981) and the second period (1987 to 2010). In 1995, though, the Great Hanshin Earthquake happened, and the progress has gradually been seen as the reconstruction of Kōbe Port progresses.

Airport Sites: Former Munich Airport, Etc.

An airport occasionally moves to suburbs due to a shortage of capacity caused by increased aviation demand or airport noise problems.

The main airport in Munich, the capital of Bavaria in southern Germany, is currently the Franz Josef Strauss International Airport, about 28 km northeast from the city. This airport was opened in 1992, and before that, the main airport was Riem Airport, located 10 km east from the city.

Riem Airport was opened to replace South Riem Airport in 1939 as one of the most modern airports in those days and was used as a military base during the World War II. It was requisitioned by the Allied Forces but restored to West Germany in 1948. Thanks to the progress of postwar reconstruction and high-level economic growth in Germany where Munich was one of the engines, the business and private usage of the airport grew. There are two airstrips of 2,800 m and 814 m, and their capacities seemed to reach their limit by the early 1950s, when the dense operation was regarded as problematic. Beginning in the late 1950s, a series of fatal aviation accidents occurred, and the airport congestion was regarded as an indirect cause.

The number of airport users drastically increased; 800,000 in 1960 became 6 million in 1980 and 11.4 million in 1990. Although the airstrips were extended to deal with the increasing number of plane departures and arrivals and the terminal building was also enlarged, the capacity of the airport could not keep up with the increasing number of users. Riem Airport was reaching the end of its functional life span. As it was difficult to enlarge the site, it was decided that a new airport would be constructed, and Riem Airport was closed in 1992.

The site of the old Riem Airport is currently a 565-hectare redevelopment district consisting of an international trade fair venue (Messestadt Riem), residential and commercial areas, research institutes, and parks. The parks occupy 200 hectares of the space, which is abundant with green. In the Messestadt Riem venue, which started operation in 1998, about 30 international exhibitions are held every year and the number of visitors is 2 million a year.

In Japan also, there are several cases of land development after airport relocation. The former Kitakyūshū Airport was constructed as an army airfield in the current Kokura Minami Ward of Kitakyūshū City in 1944. Private usage of this airport was fairly developed in the postwar period, but the number of users later stagnated because the 1,500-meter airstrip was short (though it was later extended to 1,600 m), and from the perspective of environmental conservation, it was difficult to extend it to the 2,500 m that jet crafts require. After that, an artificial island was constructed off the shore of Kitakyūshū City using dredged soil of sea routes, and a new airport was installed there. The former Kitakyūshū Airport was closed in 2006 after its functions had been transferred to the new airport, and big hospitals, industrial zones, and commercial facilities are being introduced there.

Renovation and Application of Canals

Recent cases of use conversion and site redevelopment of infrastructure in urban areas strongly reflect the tendency to respond to increased social needs for improvement of the urban environment. Especially in cases outside Japan, green and waterside environments are greatly emphasized in infrastructure reformation. From that viewpoint, the change in usage of canals originally established as main transportation routes in many countries is noteworthy. As written in Chapter 1, Lingqu, a big canal connecting the south and north People's Republic of China constructed by Qin Shi Huang (the first emperor of the unified China) in the Qin dynasty, is currently utilized as a great sightseeing resource. There are also similar cases of canals built in the modern age.

The representative example is England. In England, waterway transport using natural rivers had been developed since ancient times. Since the 17th century, natural rivers were improved to be channels and used for mass cargo shipment. In the 1790s after the Industrial Revolution, there was an enthusiastic canal construction rush, called "canal mania," and the canal network grew to over 6,000 km nationwide. But it fell into disuse because the railway appeared in the 19th century. Long after that, recreational use of canals started to emerge from the 1950s when reconstruction after World War II was settled. Businesses providing canal cruise services have been developed widely, and there are over 20,000 private ownerships of "narrowboats" that can pass through sluice gates because special licenses are not required. A public organization, British Waterways, controls canal operation. It issues licenses for canal usage and provides ship owners services such as water supply to ships and management of waste processing facilities.

In Japan, while houseboats on the Sumida River and Kanda River cruises have been popular recently, promotion of recreational usage of urban rivers remains a future issue. Such a trend seems to be happening. The Nakagawa Canal had functioned as a main cargo transport route in Nagoya City until around 1960, but it is no longer substantially used. The direction of renovation for this canal has been debated since the

1990s. Based on that discussion, Nagoya City and Nagoya Port Authority announced the Nakagawa Canal Renovation Plan in 2012, which includes redevelopment of the waterfront.

Retirement and Disposal

Infrastructure that has reached the end of its life span stops providing its services. Huge structures are used for different objectives (one of the abovementioned cases is the East Japan Railway Company's passenger transport using railroads previously used by freight lines), removed to use the empty land for different objectives (urban renovation using the remaining site of water purification plants, etc.), or abandoned (the case of discontinued railways).

Unused tangible properties must be processed in accounting. There are two approaches: retirement (of fixed assets) and disposal (of fixed assets). Roughly, when a business entity continues owning a facility after it has come to the end of its life span, the accounting treatment called retirement is needed. When a business entity decides to get rid of a facility, for example by demolishing it, they must use disposal as the accounting treatment. The orders such as Regulation on Accounting in the Railway Business or Regulation on Accounting in the Expressway Industry, etc. describe policies for practical treatment of these issues. Infrastructure business entities will process their infrastructure on the books by following these accounting regulations. Described below are matters common to various infrastructure systems in this process.

"Retirement" means the change of the category on account ledgers when the unnecessary assets continue to be held. "Assets subject to retirement" are to be moved from "business property" to "other property" on balance sheets. This means that the facility (property) is removed from business property that generates revenue. The difference of the acquisition cost and accumulative depreciation value and the current price are calculated and the smaller one becomes the book value of "assets subject to retirement." That is, the lower value in comparison between the theoretical present value excluding the depreciation and the actual current price must be chosen as the book value. Of course, the book value is lower than the asset value that was recorded before as a business asset. The loss caused by the retirement of property is a special loss booked in the profit-and-loss statement.

"Disposal" is an accounting process used when spent infrastructure is not held but is demolished and restored to the original state of the land. In this case, the property is removed from balance sheets and the loss caused is allocated as a loss on disposal of assets in the profit-and-loss statement.

When retirement or disposal require costs, it is also processed as "loss on retirement of fixed assets" or "loss on disposal of fixed assets." The processing cost for large assets such as infrastructure or heavy manufacturing factories tends to be big, and they are often not demolished but are left standing even after finishing their function.

Bibliography

Section 6.1

Choate, P. and S. Walter. 1981. *America in Ruins: The Decaying Infrastructure*. Durham: Duke University Press.

Section 6.3

Vose, D. 2008. *Risk Analysis: A Quantitative Guide, 3rd Edition*. Wiley.

Chapter
7

International Cooperation for Developing Infrastructure Projects

Now, we are creating history. The world is looking at us.

— Ferdinand de Lesseps (1805–1894),
the French diplomat who developed the Suez Canal.
With these words, he encouraged and raised the spirits
of workers with sweat dripping from his brow
at the construction site in the desert.

7.1 Official Development Assistance to Developing Countries

7.1.1 Recent Trends of Development Economics and Major Characteristics of Development Aid of Japan

One of Japan's major strategies in international cooperation for infrastructure projects is the contribution to developing countries through infrastructure development.

Japan has developed suitable infrastructure to respond to the needs of its own economic development stage. Along the way, Japan has accumulated huge experiences in planning, execution, construction, operationalization, maintenance, and disposal. After World War II, it prioritized recovering and developing infrastructure for transportation and power and energy, as well as industrial infrastructure, which led to high economic growth. This rapid growth in such a short period has been called the Japanese miracle, which later fueled economies of other Asian economies, called the Asian newly industrialized economies (Asian NIEs), i.e., the Republic of Korea; Taipei,China; Singapore; and Hong Kong, China, and helped to realize the "East Asian miracle." That is now considered an economic development model for developing countries.

Japan's aid strategies for developing countries, particularly in Asia, have focused on industrial infrastructure of transportation and energy and power by transferring knowledge from its experiences. The strategies have helped those recipient countries to establish their foundation for economic growth, which has contributed to the growth of some of the Asian developing countries and the alleviation of poverty in those countries. Japan's aid provision to those countries' growth through developing industrial infrastructure has unique features.

This chapter presents an overview of recent trends of development assistance in the world from the view of development economics and identifies characteristics of Japan's aid to developing countries and its position in the trends.

Roles of Infrastructure in Development Economics

Development economics aims to identify and investigate causal factors of poverty in developing countries and to discover approaches to alleviate poverty when formulating aid strategies for those countries. This academic area progressed after developed countries started providing aid after World War II to developing countries for their reconstruction. The aid policies may reflect philosophies of development economics.

Theories of development economics imply the difficulties of achieving two different objectives together: economic growth of developing countries, which is more relevant to macroeconomics, and reduction of disparities and poverty, which are more related to microeconomics. Mainstream theories in development economics have shaped opinions on both. Let us review the trends until now.

In the 1950s and 1960s, when development aid including assistance for postwar reconstruction started, the linear stages theory was mainstreamed. One example of this linear stages view is the stages of the economic growth model of Walt Whitman Rostow, an economic historian in the United States. The theory is that economic growth will be achieved following procedural patterns if investments are made at the right time. Subsequently, trickle-down effects occur and this reduces disparities among populations. The "trickle-down effect" explains a situation where the wealth of wealthier people will be distributed automatically to poorer ones.

However, despite investments in many developing countries, those countries' average national incomes did not rise as anticipated. That could be attributed to three factors: (i) structural (shortage of well-developed transportation infrastructure), (ii) institutional (poorly developed markets of commodities and financial services), and (iii) behavioral (insufficient educated and trained human resources). Those issues muted the effects of investments on those countries' national income growth. This finding reminded people that insufficient infrastructure development is a deep-rooted critical structural reason for developing countries' lack of growth and raised the aid community's attention to focus on infrastructure development.

In the 1970s, economic growth was believed to be achieved through industrialization. Countries prioritized transforming from the conventional farming-based economic structure to the modern industry-based economic structure. The assumption was that the expected industrialization would not only generate employment opportunities in the industrial sectors but would facilitate the movement of labor forces from rural to urban areas. To materialize the assumption, the development of industrial infrastructure including transportation and energy and power was considered essential to support the industrialization process.

In the 1980s, market-based development became prevalent, which led to the rapid growth of the Asian NIEs, including the Republic of Korea; Taipei,China; Singapore; and Hong Kong, China. The neoclassical economic growth theory became dominant in development economics, whereby competition in market mechanisms should be promoted in developing countries along with eliminating subsidies and regulations from their governments. Developing economies questioned the conventional approach whereby economic development plans were made and public state-owned enterprises implemented them. They regarded market mechanisms for economic growth and introduction of private energy as important. During this decade, strengthening education and health sectors in developing economies featured prominently in the aid community rather than the sovereign-based development of economic infrastructure.

In the 1990s, environmental issues attracted more attention from the international community, which formulated consensus among countries on aiming at sustainable growth. In the past decade, various approaches were implemented based on market mechanisms, incorporating the essence of neoclassical economic growth theory. However, such approaches did not work well and worsened the livelihoods of poor populations. Hence, in the 1990s, the international community paid attention to poverty reduction, and major international summits set a goal of reducing the number of extremely poor people.

In September 2000, the United Nations (UN) Millennium Summit was held with representatives from 189 countries. The UN adopted the UN Millennium Declaration (the declaration) as a common goal of the international community in the 21st century. The declaration set out the Millennium Development Goals (MDGs), consisting of targets such as reduction of extreme poverty and hunger, achievement of primary education, empowerment of women and girls, and gender equality, and its target year was set to 2015. The MDGs were an integrated aim considering development trends focusing on poverty reduction and directed aid more to primary education and health than to industrial infrastructure development. The MDGs' achievements were reviewed and redeveloped as the Sustainable Development Goals (SDGs) at the UN Sustainable Development Summit in September 2015 (Table 7.1).

As such, the latest trends of development economics regard poverty reduction, the core of the MDGs and SDGs, as important. In development assistance, social infrastructure related to education and health have been the focus.

The trends are in line with the recent aid allocation. Table 7.2 indicates the sectoral share of the official development assistance (ODA) from the main member countries of the Development Assistance Committee (DAC), a committee for development assistance in the Organisation for Economic Co-operation and Development (OECD). The United States (US) and European countries allocate their assistance to social infrastructure (education and health) as well as for humanitarian assistance, which is the same as the allocation patterns of Australia and the Republic of Korea.

Table 7.1: The Sustainable Development Goals (SDGs)

Goal 1: No Poverty	• Economic growth must be inclusive to provide sustainable jobs and promote equality.
Goal 2: Zero Hunger	• The food and agriculture sector offers key solutions for development, and is central for hunger and poverty eradication.
Goal 3: Good Health and Well-Being	• Ensuring healthy lives and promoting the well-being for all at all ages is essential to sustainable development.
Goal 4: Quality Education	• Obtaining a quality education is the foundation to improving people's lives and sustainable development.
Goal 5: Gender Equality	• Gender equality is not only a fundamental human right, but a necessary foundation for a peaceful, prosperous and sustainable world.
Goal 6: Clean Water and Sanitation	• Clean, accessible water for all is an essential part of the world we want to live in.
Goal 7: Affordable and Clean Energy	• Energy is central to nearly every major challenge and opportunity.
Goal 8: Decent Work and Economic Growth	• Sustainable economic growth will require societies to create the conditions that allow people to have quality jobs.
Goal 9: Industry, Innovation, and Infrastructure	• Investments in infrastructure are crucial to achieving sustainable development.
Goal 10: Reduced Inequalities	• To reduce inequalities, policies should be universal in principle, paying attention to the needs of disadvantaged and marginalized populations.
Goal 11: Sustainable Cities and Communities	• There needs to be a future in which cities provide opportunities for all, with access to basic services, energy, housing, transportation, and more.
Goal 12: Responsible Production and Consumption	• Ensure sustainable consumption and production patterns.
Goal 13: Climate Action	• Climate change is a global challenge that affects everyone, everywhere.
Goal 14: Life Below Water	• Careful management of this essential global resource is a key feature of a sustainable future.
Goal 15: Life on Land	• Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.
Goal 16: Peace, Justice, and Strong Institutions	• Access to justice for all, and building effective, accountable institutions at all levels.
Goal 17: Partnerships for the Goals	• Revitalize the global partnership for sustainable development.

Source: United Nations. 2015. *Sustainable Development Goals*. New York. https://www.un.org/sustainabledevelopment/sustainable-development-goals/.

Table 7.2: Sectoral Share of Official Development Assistance (2014)
(%)

	Social Infrastructure	Economic Infrastructure	Production	Program Assistance	Debt Relief	Humanitarian Aid	Unspecified
France	37.1	23.5	5.1	3.1	0.3	0.5	30.3
Germany	33.0	36.1	6.7	1.2	2.6	5.7	14.6
United Kingdom	51.8	8.4	4.4	0.1	0.1	13.7	21.6
United States	48.2	4.4	5.9	2.4	...	24.6	14.4
Australia	49.1	6.5	4.5	0.8	...	8.1	31.1
Republic of Korea	40.7	34.2	10.8	0.0	...	3.1	11.3
Japan	17.1	48.9	9.9	4.1	...	6.9	13.1
DAC Countries	37.3	19.3	6.9	2.1	0.6	12.2	21.7

Source: Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC).

Japan's Development Assistance Prioritizing Industrial Infrastructure Development

Then, what are the major characteristics of Japan's development assistance? Previous studies revealed the following two.

The first characteristic is that the share of aid allocated to industrial infrastructure, such as roads, ports, and power plants, is significant. As shown in Table 7.2, the focus of the US and European countries is on social infrastructure like education and health, while Japan has allocated about half of the amount to assist in the development of industrial infrastructure.

The second characteristic is that Japan provided assistance in the form of loans more than in the form of grants. Though most of the official development assistance from the US and European countries have been grants, the share of grants in Japanese official development assistance has been limited to half of the total assistance, significantly low among the DAC member countries. This could be because its development assistance has been for the development of industrial infrastructure, roads, ports, and power plants, which may require a huge amount to be allocated for an individual project. This may eventually make grant assistance difficult and increase the share of yen loans involving borrowers' repayments.

Japan's development aid for industrial infrastructure using yen loan schemes has been implemented in line with the government's development aid policies. For example, the ODA White Paper 2005 indicates about the country's infrastructure-centered aid: "Japan has

Box 7.1: Multilateral Development Banks' Development Assistance

Multilateral donors have been a pillar for supporting developing countries' efforts to promote growth and development for many decades, with recognized strengths in extending the scale and reach of development finance and mobilizing knowledge and know-how. The ambitious Sustainable Development Goals call for inclusive partnerships that will provide collective, cross-border solutions for eradicating absolute poverty and fostering a new era of economic and social progress, environmental sustainability, and peaceful and inclusive societies. Multilateral organizations are uniquely equipped to support this agenda: they are politically neutral conveners of global partnerships, vehicles for upstream pooling of resources, facilitators for multi-stakeholder cross-border operations, and setters of global standards and norms.

To be fit for the Sustainable Development Goals, multilateral development banks continue to implement ongoing institutional reform programs, such as the UN's 2012 Quadrennial Comprehensive Policy Review and the World Bank Group's organizational restructuring and ongoing trust fund reform. New multilateral organizations are emerging along new geopolitical axes; examples are the Asian Infrastructure Investment Bank and the New Development Bank. New vertical funds are also emerging; an example is the Green Climate Fund, which has a quasi-universal membership of advanced economies and developing countries with an equal voice. In this context, multilateral organizations will need to demonstrate and enhance their comparative advantages and reinforce cooperation and information-sharing to reduce risks linked to increased competition, volatility of funding to developing countries, and possible funding gaps.

Source: Organisation for Economic Co-operation and Development. 2015. *Multilateral Aid 2015: Better Partnerships for a Post-2015 World*. OECD Publishing: Paris. https://doi.org/10.1787/9789264235212-en.

long insisted that economic growth through infrastructure development, etc., is crucial to poverty reduction, and has incorporated this viewpoint in its ODA policies. East Asia provides a good example of where developing countries have forged a path toward achieving the MDGs, ODA has contributed to building the foundation for economic growth, and as a result, poverty has been declining."

In fact, East Asian economies including the Republic of Korea, the People's Republic of China (PRC), and the Association of Southeast Asian Nations (ASEAN) countries were provided with continuous assistance in infrastructure development by Japan. Their economies have been growing steadily, which led to the continuous expansion of their share of the global economy. At the beginning of their growth, the development of industrial infrastructure was prioritized for investments.

It has now contributed to bringing in foreign direct investment (FDI) and facilitating industrial promotion, which led to economic growth and poverty reduction.

Inducing FDI from a donor country following ODA provision is called the vanguard effects of ODA. Japan's ODA prioritizing the development of industrial infrastructure has been recognized to promote FDI from Japan to the ODA recipient countries. Its FDI has been recognized as one major contributing factor to the economic growth of Asian countries, particularly in Southeast Asia. Japan's ODA has contributed to those countries' development through FDI.

Those experiences of its ODA have recently attracted attention to the roles of infrastructure development in poverty reduction, and not only Japan but multilateral institutions like the World Bank have been researching interrelations between development assistance and infrastructure. For example, Japan and the World Bank jointly organized the Annual World Bank Conference on Development Economics in 2006 and facilitated comprehensive discussions on the role of infrastructure development for economic growth and poverty reduction under the theme Rethinking Infrastructure for Development. The government presented the results of research on its aid and the effects observed in Asian countries, with which roles of infrastructure in development were further discussed by scholars and professionals at the conference.

Box 7.2: Asian Development Bank's Strategy 2030

The new long-term corporate strategy to 2030—Strategy 2030—sets the course for the efforts of the Asian Development Bank (ADB) to respond effectively to the region's changing needs. Strategy 2030, which was proposed at its 51st Annual Meeting in May 2018 and published in July 2018, reflects feedback from a wide range of stakeholders, including policy makers in developing and developed countries, academics, and civil society organizations, as well as ADB Board members and staff.

Under Strategy 2030, ADB will sustain its efforts to eradicate extreme poverty, given the region's unfinished poverty agenda, and expand its vision to achieve a prosperous, inclusive, resilient, and sustainable Asia and the Pacific. It will help the region prosper by sustaining economic growth with quality and creating job opportunities. ADB will promote inclusiveness to ensure that economic gains are widely shared. It will support the resilience and sustainability of countries, especially for vulnerable populations.

Source: Asian Development Bank. *Strategy 2030: Achieving a Prosperous, Inclusive, Resilient, and Sustainable Asia and the Pacific.* Manila: Asian Development Bank. http://dx.doi.org/10.22617/TCS189401-2.

7.1.2 Assistance in Infrastructure Development through International Cooperation

Basic strategies of Japan's development assistance (ODA policies) are determined in the Overseas Economic Cooperation Council under the Cabinet Office. The Ministry of Foreign Affairs and the relevant ministries jointly formulate assistance plans and the Japan International Cooperation Agency (JICA) takes the responsibility for implementing the plans.

One primary strategic tool of the government for international expansion of infrastructure projects is international cooperation. The following is a glance at international cooperation schemes from that perspective.

International cooperation is broadly defined as a support to people in developing countries and regions for peace, stability, and development of the international society, and many players are involved, including the government, private sector, nonprofit and nongovernment organizations, and local authorities. Funds for international cooperation are categorized into three types: official development assistance, other official flows, and private finance. There are two measures: bilateral cooperation by the government with developing countries and multilateral cooperation through international financial institutions (IFIs).

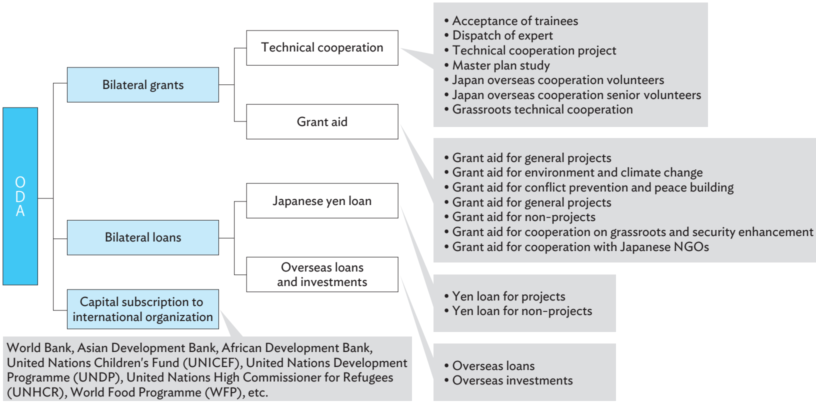
7.1.2.1 Official Development Assistance

Amongst those, ODA plays the biggest role in Japan's international cooperation. Figure 7.1 shows the breakdown of ODA in 2014, indicating the amounts of bilateral assistance through grant assistance and technical cooperation yen loans, while multilateral assistance was also made for investing in or contributing to IFIs.

(i) **Bilateral grants.** Bilateral grants are a type of assistance to developing countries without any charge or requirement for repayment, which can be categorized into grant assistance and technical cooperation. This assistance is for countries whose income levels are very low compared to other developing countries, and target sectors are the primary sectors such as health and infectious diseases, sanitation, water supply, education, and agricultural development, and sometimes include small-scale infrastructure of water supply or roads.

Technical assistance aims at assisting in training human resources for social and economic development in developing countries by providing Japan's technologies,

Figure 7.1: Contents of Official Development Assistance



NGO = nongovernment organization, ODA = official development assistance.
Source: White Paper on Development Cooperation (Japan's ODA White Paper).

skills, and knowledge. This scheme is to help the formulation of development plans, including infrastructure, by sending technical experts of areas. Under the scheme, a mission from JICA normally visits the recipient country's government to discuss and confirm the scope of work of a planned project. The project team again confirms with the government's executing agencies on the project's objectives and scope and summarizes their agreement in the form of an inception report. Subsequently, with the agencies' officials, the project team prepares an interim report at the midpoint of the project and a final report at the final stage to close the project.

(ii) **Bilateral loans (yen loans).** Bilateral loan schemes are on the assumption that developing countries will repay in the future. In Japan's case, these are called yen loans. Yen loans are categorized into three: project loans, non-project loans, and debt relief. Out of the three, the project loan is the most relevant scheme to infrastructure development, which is to finance projects for developing infrastructure, such as power or gas, roads, railways, ports, telecommunications, and industrial parks, and accounts for most yen loans.

The interest on yen loans is normally low, and the amortization period is long for developing countries' repayment. This scheme aims at enhancing those countries' ownership of projects through repaying loans. Receiving a yen loan is expected to enhance the country's commitment to its own development through developing infrastructure for facilitating the growth of its society and economy. Japan has been implementing international cooperation projects through yen loan schemes in Asian countries, which has been acknowledged as a factor contributing to the countries' recent growth.

7.1.2.2 Other Official Flows

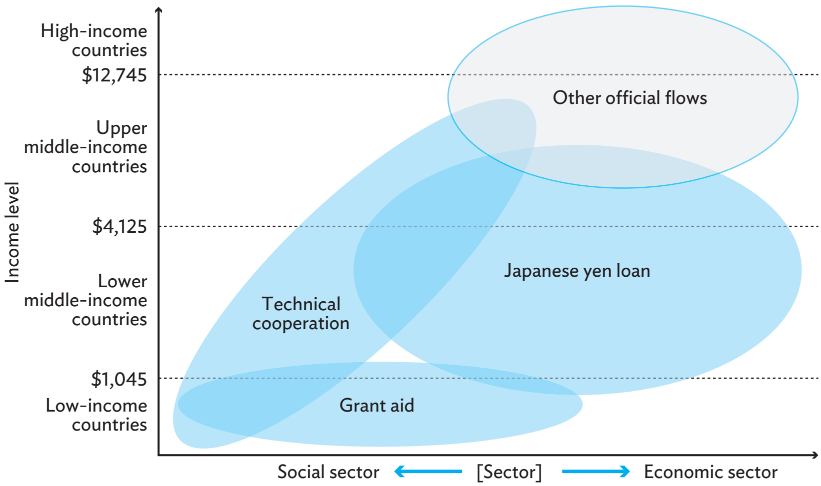
Japan's international cooperation has been made through official development assistance, while there are other financial schemes for private companies' support to infrastructure development or participation in relevant projects as stakeholders whereby the government guarantees credit to those companies. The major example is export finance of the Japan Bank for International Cooperation (JBIC). JBIC is a bank which is completely sponsored by the government for its operation while keeping its independence. It is an institution specialized for international finance with responsibilities for formulating and implementing the country's overseas economic policies and energy security policies.

Export loans by JBIC are a financial scheme for exporting and selling machines, plants, and technologies of Japanese companies, which are to be provided to foreign importing companies (purchasers) or financial institutions. The scheme secures a stable supply of vessels and power plants or essential resources and energy and covers some infrastructure development projects. Countries under the scheme are mainly developing countries or middle-income countries, but can be high-income countries as well for projects to export infrastructure like railways (urban/inter-city), water supply, biomass fuel production plants, renewable energy power generation facilities, nuclear power plants, transmission/distribution networks, high-efficiency coal power generation plants, coal gasification facilities, carbon dioxide capture and storage, high-efficiency gas turbine generation plants, and smart-grid utilities.

7.1.2.3 Characteristics of Official Development Assistance and Other Official Flows

The coverage of ODA and other official flows (OOF) are illustrated in Figure 7.2 on national income levels and areas for assistance. ODA is for countries of low income levels and its major areas are social sectors. Looking into recipient countries' gross national income (GNI), grant assistance is for countries with GNI per capita below $1,500, yen loans are for countries with GNI per capita below $5,000, and technical assistance is for countries with GNI per capita below $10,000.

Figure 7.2: Targets of Official Development Assistance and Other Official Flows



Source: Prime Minister's Office.

On the other hand, OOF is for countries of high-income levels and large-scale projects. As mentioned above, OOF is applicable for infrastructure development projects. This implies that OOF is more flexible to be offered to respond to needs of countries, particularly related to infrastructure development projects. However, it's not concessional, indicating that its interest rate is higher than those of yen loans, and its amortization period is shorter.

7.1.2.4 Other Countries and Multilateral International Cooperation

Other developed countries also carry out development assistance in the framework of international cooperation. As examples of bilateral international cooperation, there are a variety of institutions, such as the United States Agency for International Development, the Department for International Development for the United Kingdom, Agence Française de Developpement for France, Deutsche Gesellschaft für Internationale Zusammenarbeit for Germany, and Korea International Cooperation Agency. Those agencies are like JICA with institutional responsibilities for providing financial and technical assistance to developing countries.

There are multilateral development assistance agencies as well, including the United Nations Development Programme (UNDP), the International Bank for Reconstruction and Development (IBRD), the World Bank, and the Asian Development Bank (ADB). In 2015, the

Box 7.3: Introduction of the New Development Bank

The New Development Bank (NDB) is a multilateral development bank established by Brazil, the Russian Federation, India, the People's Republic of China, and South Africa with the objective of financing infrastructure and sustainable development projects in those countries and other emerging economies and developing countries, complementing the efforts of multilateral and regional financial institutions toward global growth and development.

Founded on 7 July 2015, the main objectives of NDB's operations are fostering development of member countries, supporting economic growth, promoting competitiveness and facilitating job creation, and building a knowledge sharing platform among developing countries. To fulfill its purpose, NDB will support public or private projects through loans, guarantees, equity participation, and other financial instruments.

In 2016–2017, the Board of Directors of the Bank approved loans involving financial assistance of over $3.4 billon for projects in the areas of green and renewable energy, transportation, water sanitation, irrigation, and other areas.

Source: New Development Bank. https://www.ndb.int/.

Asian Infrastructure Investment Bank (AIIB) was established as a new multilateral agency, led by the PRC, to provide financial assistance to increasing needs for building infrastructure in Asian countries. At the time of establishment, 57 countries joined as shareholders, but Japan and the US did not join as of May 2018.

Insufficient funds for investments in infrastructure development have been recognized as one impediment of the growth of developing countries. Hence, the AIIB has been appreciated as a new funding source. Per ADB's estimate, around $8 trillion would be required for developing infrastructure in Asia at the necessary level, which would be beyond

Box 7.4: Asian Development Bank Estimation of Investment

The Asian Development Bank estimated that developing Asia will need to invest $1.5 trillion per year in infrastructure through 2030 to maintain its economic growth momentum and tackle poverty. This number increases to $1.7 trillion per year if one takes into account the efforts needed to tackle climate change, both in terms of mitigation and adaptation.

Source: Yoshino, N., M. Helble, U. Abidhadjaev, eds. 2018. *Financing Infrastructure in Asia and the Pacific: Capturing Impacts and New Sources.* Tokyo: Asian Development Bank Institute. https://www.adb.org/publications/financing-infrastructure-asia-capturing-impacts-and-new-sources.

the existing agencies' capacity. The AIIB still must clear issues related to institutional governance and criteria on loan examination, but its contribution to increases in financial resources facilitates investments in infrastructure development in Asia.

7.1.2.5 Tied Assistance and Untied Assistance

Financial assistance, both yen loans and grant assistance, are categorized into tied and untied assistance on the procurement of goods and services. Tied assistance is a conditional scheme at procurement, which limits procurements to the donor country. That is called "restricted" assistance. On the other hand, under the untied assistance scheme, procurement is executed through international competitive bidding.

In 2001, the DAC of the OECD issued a recommendation to untie ODA to the least developed countries. The recommendation was also applied to the heavily indebted poor countries in 2008.

Generally, untying bilateral official development assistance is considered to enhance aid effectiveness through reducing transaction costs. On the other hand, a reason that many donor countries, especially in the case of bilateral assistance, employed tied assistance was their expectation for expanding the countries' export volumes to recipient countries through the assistance, benefiting their domestic companies and promoting the accountability of ODA.

Japan used to procure goods and services through international competitive bidding in most yen loan projects, resulting in a larger share of untied aid among the total assistance than other countries. Recently, the country has set a goal of "visible assistance" and employed the Special Terms for Economic Partnership (STEP) scheme where the domestic companies' subsidiaries are accepted as primary contractors. This change has been increasing the share of tied aid projects.

7.1.3 Needs for Infrastructure along Developing Countries' Development Stage

A country's development process and its needs for infrastructure are closely interlinked, which is vital when considering the contribution of infrastructure development to developing countries. Countries targeted for international expansion of infrastructure projects have their own needs for infrastructure at their economic development stages, and it is essential to take the countries' immediate needs into account when selecting infrastructure for investment and formulating its appropriate technical specifications.

The development stage of a country is categorized in accordance with patterns introduced by the World Bank. The World Bank categorizes countries into four groups according to indicators including their GNI per capita. This indicator, or gross domestic product (GDP) per capita, represents the average income level per capita of a country. It has a limitation of not being able to show disparities on incomes among populations, but the correlation between the GNI and the country's development level has been confirmed: when the GNI per capita exceeds $3,000, the use of consumer durables like electronic appliances increases, and when its value exceeds $5,000, the number of owners of vehicles increases.

The four groups are low-income countries for countries with a GNI per capita of $995 or less in 2017, lower middle-income countries for countries with a GNI per capita between $996 and $3,895, upper middle-income countries for countries with a GNI per capita between $3,896 and $12,055, and high-income countries for countries with a GNI per capita of $12,056 or more (see Table 7.3). The progress of industrialization and living standards vary upon income levels, indicating that priorities and technical specifications of infrastructure for supporting the countries' economies should be varied upon national economic levels.

The PRC and India are gigantic, which causes differences in the development progress among the regions and requires caution on the types and levels of infrastructure that each region requires. Other countries set their priority areas for their nationwide development. Examples include metro areas like capitals or areas designated for special development purposes like industrial parks or free trade zones.

The following section looks at the development of infrastructure in the three groups of low-income countries, lower middle-income countries, and upper middle-income countries. The infrastructure development is often subject to each country's contexts, and the analysis below is only a summary of general trends observed in the three groups.

7.1.3.1 Low-Income Countries

The category of low-income countries includes Bangladesh and Cambodia, which have slowly progressed within Asia, and most of the African countries, particularly sub-Saharan African countries like Ethiopia, Tanzania, Kenya, Angola, and Mozambique. These countries must tackle immediate issues related to people's quality of life, such as food crises and lacking facilities to provide health and basic education. Hence, infrastructure for development is expected to help mitigate those issues, and the investment goes to develop infrastructure for improving the quality of people's life, such as water supply facilities for securing

Table 7.3: Classification of Economies by Income Level and Infrastructure Development

	Emerging Economies			High-Income Economies
	Low-Income Economies	Middle-Income Economies		
		Lower	Upper	
Income Level GNI/capita ($) 2019	$995 or less	$996–$3,895	$3,896–$12,055	$12,056 or more
Number of economies/ areas	34	47	56	81
Economies/ Areas	Benin	India	China, People's Rep. of	G7 countries
	Comoros	Indonesia	Malaysia	EU countries
	Nepal	Lao PDR	Thailand	Korea, Rep. of
	Tajikistan	Myanmar	Turkey	Taipei,China
	Democratic Republic of the Congo	Mongolia	Belarus	Hong Kong, China
	Ethiopia	Pakistan	Bulgaria	Singapore
	Tanzania	Philippines	Kazakhstan	Brunei Darussalam
	Madagascar	Ukraine	Romania	Australia
	Mozambique	Uzbekistan	Brazil	New Zealand
	Rwanda	Bolivia	Columbia	Norway
	Uganda	Honduras	Jamaica	Switzerland
	Zimbabwe	Egypt	Mexico	Czech Republic
	etc.	Morocco	Peru	Poland
		Cameroon	Venezuela	Chile
		Republic of the Congo	Algeria	Puerto Rico
		Ghana	Iran	Uruguay
		Nigeria	Iraq	Bahrain
		Sudan	Jordan	Israel
		Zambia	Libya	Kuwait
		etc.	Botswana	Oman
			Mauritius	Saudi Arabia
			South Africa	United Arab Emirates
			Armenia	
			Samoa	
			Cuba	
			etc.	
Stage of infrastructure development	Sectors related to fundamental life including water, fundamental education, and medical care	Sectors related to industrial promotion including electricity, road, rail, port, airport, telecommunication, and industrial park	Sectors related to industrial promotion with advanced technology including ITS (intelligent transport systems), high speed rail, EDI (electric data exchange), air traffic control, smart community	In addition to advanced industrial sector, cutting edge field including energy saving, renewal energy, advanced waste treatment, disaster prevention, advanced medical care, space systems such as quasi-zenith satellite system Rehabilitation and maintenance of existing infrastructure

Source: World Bank. World Development Indicators. Washington, DC.

safe drinking water, roads for providing access to medical facilities, and transportation for accessing basic education facilities like elementary and junior high schools.

7.1.3.2 Lower Middle-Income Countries

The category of lower middle-income countries includes those with slow progress in industrialization, such as the Lao People's Democratic Republic and Mongolia in Asia, Egypt and Morocco in North Africa, and newly industrialized or resource-rich countries of large population, including India and Indonesia in Asia, and Ghana, Sudan, Nigeria, and Zambia in Africa. People of these countries can satisfy the basic needs for their livelihoods, but often face needs for industrial promotion to improve living standards and reduce income disparities inside the countries. Hence, the major infrastructure for development is related to industrial infrastructure, including electricity, roads, railways, ports, airports, telecommunications, and industrial parks. It is normally unrealistic to proceed with the development of those infrastructure components over the country at once, considering their limited capacities and financial resources. The countries often designate special economic areas like free trade zones for priority investments.

7.1.3.3 Upper Middle-Income Countries

Most of the upper middle-income countries are industrialized like the PRC, Thailand, and Malaysia in Asia, Mexico, Brazil, and Argentina in Latin America, and Romania and Bulgaria in Eastern Europe, where many families can afford to purchase private vehicles. Most of basic infrastructure, including electricity, roads, railways, ports, airports, and telecommunications, is well developed in areas designated as prioritized for development, and the development could be expanded to other regions within their countries. They intend to introduce high-tech infrastructure, including intelligent transport systems, high-speed railways, electronic data interchange, air traffic control, smart communities, and telecommunications for their further investment. Furthermore, it is acknowledged that people's environmental awareness grows when their income exceeds a certain level, which raises the country's attention to infrastructure aiming at improving the environment, like sewerage systems, or recovering the natural environment.

7.1.4 Case Studies

This section showcases Japan's major contributions to infrastructure development in four developing countries selected from the abovementioned three groups, Tanzania (low-income country), India and Indonesia (lower middle-income countries), and Thailand (upper middle-income country).

7.1.4.1 Low-Income Country Case: Water Supply Project in Tanzania

Tanzania is a republic in the eastern part of Central Africa, a part of sub-Saharan Africa. The country consists of Tanganyika in East Africa and Zanzibar, islands in the Indian Ocean, totaling 947 thousand square kilometers (km). The population is 51.8 million (2014) and the GNI in 2014 was $45.9 billion, classifying the country as a low-income country.

Since the independence in 1961 from the United Kingdom, the country's political situation stayed stable, and Tanzania recently achieved the economic growth rate of 7%, above the average rate of African countries. However, the GNI per capita remains low, and poverty reduction through economic growth is a critical issue. In this country, basic infrastructure over the country is not enough for maintaining people's life and its provision is urgently required.

Japan's ODA has contributed to developing small-scale infrastructure to maintain people's life at basic levels, such as developing water supply facilities, preventive health care and prevention of infectious diseases, constructing elementary school buildings, and widening roads. As an example, a water supply project in Tanzania helped to build water supply facilities in the metro areas around the capital (Dar es Salaam), the southern provinces (Lindi and Mtwara) and the northern provinces (Mwanza and Mara). In the Tanzania Development Vision 2025, the government of Tanzania included a target that safe and clean water is available for all populations within 400 meters from each house by 2025. At present, the water supply rate in the metro areas remains very low, with only 23%, and technical specifications on facilities to be developed under the project are limited to the basic level, including public faucet-type water supply facilities, deep wells with hand pumps, and ground water exploration equipment.

7.1.4.2 Lower Middle-Income Country Case: Delhi Metro in India

India is in the Indian subcontinent in South Asia with a land mass of 3.29 million km^2 and a population of 1.29 billion (2014), and the total

GNI is $2.036 trillion (2014). The country falls into the category of lower middle-income countries. After the country changed its development strategy to economic liberalization in 1991, economic reform, including deregulation and active involvement of foreign capital, has been promoting rapid economic growth. On the other hand, an issue has been observed: lacking infrastructure like roads, railways, power, water supply, and sewerage. For instance, insufficient electricity causes major blackouts over the metro areas.

Hence, the government of India has built infrastructure and committed to allocate a budget of about INR51 trillion ($770 billion) in the 12th five-year plan (target year: 2012–2016). The core infrastructure for investment is varied: power generation, railways, highways, urban development, ports, airports, and industrial parks.

Japan has provided yen loans through various projects, and the following showcases one successful yen loan project, the Delhi Metro Rail Project. As stated earlier, lower middle-income countries put the priority for developing infrastructure in particular areas, like metro areas. The Delhi Metro Rail Project would be a typical one.

The Delhi Metro consists of subways and elevated railways covering Delhi, the capital, and its suburban areas. The total length at the completion in the third phase in 2016 was 330 km and will be 430 km at the end of the fourth phase in 2021, which exceeds the total length of the subway networks in the city of London, 402 km. Traffic congestion has been serious in Delhi as well as in other metro areas in developing countries, and the project is expected to relieve the congestion and improve the urban environment through reducing emissions.

Japan has supported the project from the beginning. For the first phase (total length of 59 km), yen loans totaling about $1.63 billion,

Delhi Metro (India). The subways and elevated railways of the Delhi Metro should alleviate problems caused by traffic congestion and pollution in the area (photo by Japan Bank for International Cooperation).

divided into six packages, were provided. The assistance continued in the second and third phases.

At the construction of the Delhi Metro, Japan-based civil engineering consultancy companies, construction companies, and trading companies have participated, which helps to share Japan's techniques and experiences on streamlining the civil works process and controlling safety management over the process. Before the project, there was no custom or strict rule in India of wearing safety helmets and shoes during civil works. However, the Japanese construction supervision team guided and required all their site workers to wear helmets. Further, know-how on safety management and operation for smoothening construction work was familiarized to local site workers and institutionalized: the project site was separated into two, one for construction and one other purposes. Workers were obliged to wear a fluorescent construction vest and safety belt, and equipment and materials in the site were to be kept in order. Moreover, common rules in workplaces in Japan were put into place: coming to the site and starting work on time and complying with the original work schedule. These efforts made through the project were appreciated as a culturally innovative idea for conventional construction methods in India.

7.1.4.3 Lower Middle-Income Country Case: Railway Project in the Jabodetabek Area

Indonesia is a republic in the southern part of Southeast Asia, and its area covers 1.89 million km^2. The population is 255 million (2015) and the GNI per capita (2015) is $886.5, but the country is categorized as a lower middle-income country.

The country's primary economic activity is agriculture, and its primary products are rice, cacao, cassava, and coconuts. Furthermore, it is rich in mineral resources, petroleum, coal, natural gas, gold, and tin, and its industrial sector is also active in light industries, food and fabric industries, and petroleum processing. Japanese companies have been involved in those industries in the country. In the Asian financial crisis in 1997, the country was forced to execute economic reforms with the consensus of the International Monetary Fund. The economy has been on the rebound through the stabilization of the political environment and financial system and increases in individual consumption.

The development of infrastructure of roads, railways, energy, and telecommunications has been delayed in the country. In particular, Greater Jakarta, where the population density is high and many administrative functions concentrate, has experienced a significant shortage of infrastructure compared to demand, and the islands have been lacking infrastructure in the energy and transportation sectors.

Japan is the largest donor country for Indonesia and has contributed to the country's growth through technical assistance and development interventions in industrial and social infrastructure. A case of an urban railway development project in the Jabodetabek area is described below.

Jabodetabek, another name of Greater Jakarta, consists of the five areas of Jakarta (Ja), Bogor (Bo), Depok (De), Tangerang (Ta), and Bekasi (Bek). Since the 1970s, Japan has been implementing various types of development assistance for improving railways in the area. In 1972–1981, yen loans were provided for modernizing the facilities and installing diesel and electric locomotives and rolling stock.

In 1981, JICA helped to carry out the Study on Integrated Transportation Master Plan for Jabodetabek. The master plan aimed to

Urban Railway in the Jabodetabek Metropolitan Area (Indonesia). This is an example of a government-to-government framework for formulating a master plan (photo by Japan Bank for International Cooperation).

improve passenger transportation in the area where 20 million resided, including the development of approximately 150 km of urban railway networks. The plan was formulated on the assumption that existing facilities, lands, utilities, and operating institutions would be utilized for the planned improvements as much as possible. After the master plan was completed, projects to modernize urban railway networks were implemented through yen loans.

When developing several infrastructure systems in metro areas, it may be effective to formulate a master plan utilizing a government-to-government framework, such as JICA's technical assistance schemes or study schemes of the Ministries of Economy, Trade, and Industry and of Land, Infrastructure, Transport, and Tourism. The urban railway projects in Jabodetabek could be one typical project following the procedure. The projects' continuous expansion increased the number of passengers from 50,000 in 1984 to about 360,000 in 2010.

7.1.4.4 Upper Middle-Income Country Case: Eastern Seaboard and Development in Thailand

Thailand is a constitutional monarchy state located in Southeast Asia with 0.51 million km^2, a population of 67.7 million (2015), and a GNI of $363.4 billion (2014). The GNI per capita is $5,370, and the country falls into the category of upper middle-income countries. Since the 1960s, high economic growth started following industrialization with the backup of FDI from Japan and European countries, and the development of infrastructure progressed rapidly. The country overcame the Asian financial crisis, the Lehman shock, and large-scale floods, and economic growth continues smoothly.

Japan's ODA to Thailand, which has contributed to the country's economic growth, started with technical assistance in 1954, followed by a yen loan in 1968 and grant assistance in 1970. Japan is the largest total accumulated contributor to the country. The power sector, mainly hydroelectric power generation or transmission and distribution systems, was prioritized for intervention in the 1960s, and the sectors of long-distance telecommunication networks and roads were added to the priority sectors in the 1970s. Subsequently, in the 1980s, the following infrastructure was developed by yen loan schemes: urban railways, expansion of international airports, ports, rural electrification and telecommunication infrastructure, and irrigation facilities.

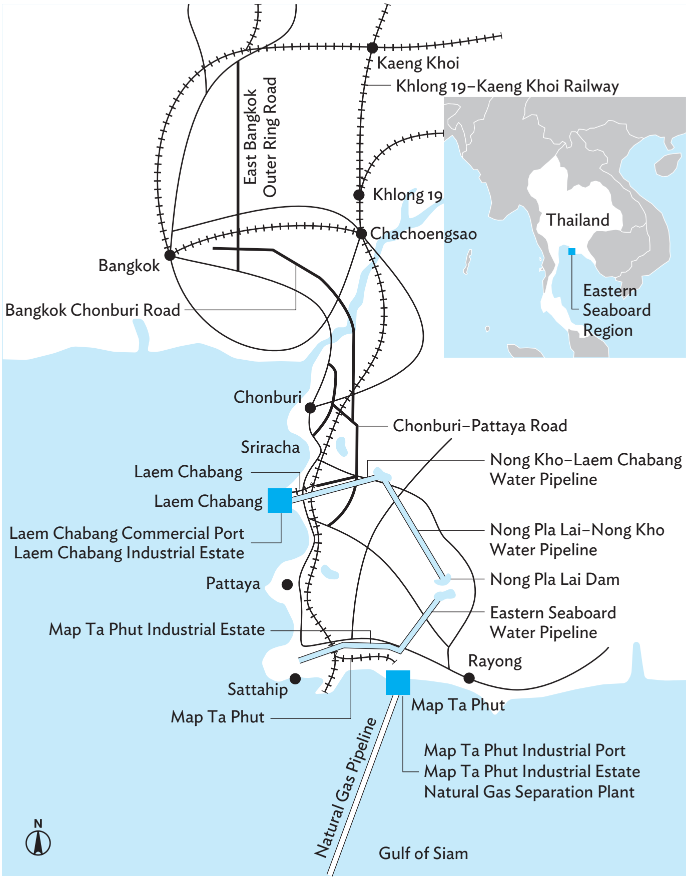
The following explains the Eastern Seaboard Development Project, particularly a component of constructing the Laem Chabang Port, which was a large-scale complex project of building industrial parks and constructing railways. The project could be a successful case to realize regional development, although it caused industrial pollution.

The Eastern Seaboard Development Project was promoted from the early 1980s until the early 1990s. The development was carried out following the experiences of developing industrial parks in Japan. It was also aimed at avoiding Bangkok centralization and directing people and industries to the eastern seaboard area, about 80–200 km southeast of Bangkok. As a result, an industrial park was established in the area. Taking this opportunity, the Thai government pushed a policy to transform its economy to export-based industrial structures. The development was a complex initiative with a core of developing natural gas in the Gulf of Siam and constructing the Laem Chabang Port. The total investments were $11.5 billion.

At that time, the Overseas Economic Cooperation Fund, responsible for yen loans, focused on the construction of the Map Ta Phut Industrial Estate and the promotion of industries in Laem Chabang and provided 16 yen loan projects covering 27 components for constructing international ports, expanding water supply networks, and constructing railways systems (Figure 7.3). The total approved amount was $1.79 billion. Those infrastructure development projects contributed significantly to the promotion of private investments in the new industrial park and the improvement of international logistics following the construction of a deep-water port. Bangkok Port, a major port for the country, was located along the Chao Phraya River, which was too shallow and narrow for large ships to enter. That caused complexities in logistics systems, where containers from Bangkok Port had to be shipped to and stored in Hong Kong, China or Singapore, regional hub ports before being transferred to European countries and the US. The Laem Chabang Port accommodates the recent growth of container transportation and enables international large-scale container-stored vessels to enter directly, which raises the country's position in international logistics markets.

On the other hand, from the environmental and social safeguards perspectives, of any development project in Thailand, this development caused the most significant adverse impacts on the natural environment and people's health conditions. The most serious issue was odor problems in the established industrial park. Odors from factories processing petroleum were a hard issue that stopped classes in junior high schools nearby and forced the schools to relocate. Building and operating large-scale petrochemical plants had not been done in Thailand, and the country had no laws or rules regulating odor and could not take the necessary measures. Afterwards, the governmental agencies, local residents, and plant operators had close communications for resolving the issue, which has helped to improve the situation. This is considered as an important lesson on environmental and social considerations in large-scale development projects.

Figure 7.3: Eastern Seaboard Development (Thailand)



Source: Japan Bank for International Cooperation.

7.2 International Infrastructure Business Development

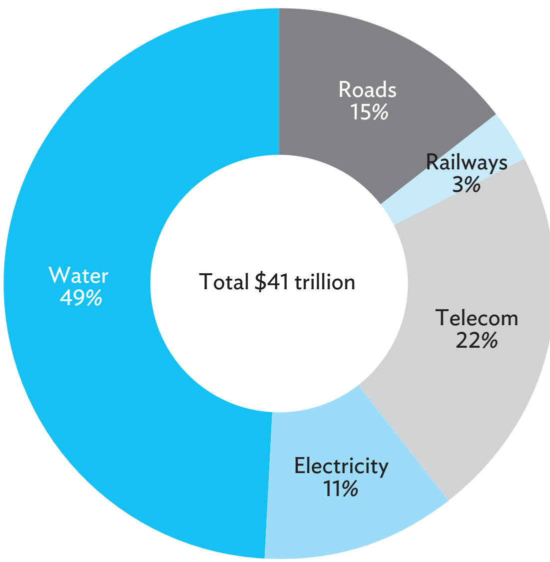
7.2.1 International Infrastructure Markets

7.2.1.1 Prospects of Infrastructure Markets in the World

It is certain that the infrastructure markets in the world will continuously grow. However, it is not easy to forecast the growth properly. The forecast could vary depending on factors including target year or sectors to be included for study.

A comprehensive study on infrastructure markets in the world has been carried out by the (Organisation for Economic Co-operation and Development (OECD). The OECD forecast in 2006 and 2012 the global scale of infrastructure markets by 2030. According to the study, the world market would grow by $41 trillion covering roads, railways, telecommunications, power, and water from 2010 to 2030, indicating annual growth of about $2 trillion. Among the sectors, the share of the water sector is the largest, 49%, followed by the telecommunication sector (22%), roads (15%), electricity (11%), and railways (3%) (Figure 7.4).

Figure 7.4: Infrastructure Market until 2030 for Telecom, Land Transport, Water, and Electricity



Source: Organisation for Economic Co-operation and Development.

In 2012, the OECD presented an estimate of the scale of the infrastructure market, including airports, ports, railways, and petroleum and gas (Table 7.4). The market scale between 2015 and 2030 could be $8.8 trillion, equivalent to $0.6 trillion per annum on average. Among those sectors, the share of the railway sector was the largest, followed by the sectors of petroleum and gas, airports, and ports.

Table 7.4: Strategic Transport Infrastructure Needs until 2030

Infrastructure Facilities	Annual Average Investment ($ billion)		Aggregate Investment ($ billion)		
	2009–2015	**2015–2030**	**2009–2015**	**2015–2030**	**2009–2030**
Airport Capital Expenditures	67	120	400	1,800	2,200
Port Infrastructure Facility Capital Expenditures	33	42	200	630	830
Railway "New Construction" (including Maintenance)	153	271	920	4,060	5,000
Oil and Gas (Transport and Distribution)	155	155	930	2,325	3,255
Total	**408**	**588**	**2,450**	**8,815**	**11,285**

Source: Organisation for Economic Co-operation and Development. 2012. *Strategic Transport Infrastructure Needs to 2030*. Paris.

7.2.1.2 Prospects of Infrastructure Markets in Asia

The following investigates infrastructure markets in Asia, where Japan has been actively involved. ADB presented their estimates in 2017 (Table 7.5). The estimate shows that infrastructure markets of the studied regions would grow by $8 trillion from 2010 to 2020, averaging around $730 billion per annum. The sectors of the largest share are energy (power) and roads, followed by telecommunications and water supply and sanitation.

Out of the entire markets, new development accounts for $5.4 trillion, while rehabilitation and reconstruction accounts for $2.6 trillion, about 30% of the total. This reveals the existence of a market for rehabilitating and reconstructing existing facilities as well as a market for new development.

7.2.1.3 Characteristics of International Infrastructure Markets

Development of infrastructure outside Japan needs to identify characteristics of demand in the markets. Those characteristics vary among countries, while some common factors may exist among infrastructure markets in developed countries, emerging countries, and developing countries in consideration of their development process.

Table 7.5: Asia's Total Infrastructure Investment Needs by Sector, 2010–2020 (2008 $ million)

Sector/Subsector	New Capacity		Replacement		Total
	Amount	Percentage	Amount	Percentage	
Energy (Electricity)	3,176,437	59%	912,202	35%	4,088,640
Telecommunications	325,353	6%	730,304	29%	1,055,657
Mobile Phones	181,763	3%	509,151	20%	690,914
Landlines	143,590	3%	221,153	9%	364,743
Transport	1,761,666	32%	704,457	27%	2,466,123
Airports	6,533	0%	4,728	0%	11,261
Ports	50,275	1%	25,416	1%	75,691
Railways	2,692	0%	35,947	1%	38,639
Roads	1,702,166	31%	638,366	25%	2,340,532
Water and Sanitation	155,493	3%	225,797	9%	381,290
Sanitation	107,925	2%	119,573	5%	227,498
Water	47,568	1%	106,224	4%	153,792
Total	**5,418,949**	**100%**	**2,572,760**	**100%**	**7,991,710**

Source: ADB. 2009. *Infrastructure for a Seamless Asia*. Manila. https://www.adb.org/publications/infrastructure-seamless-asia.

Box 7.5: Asian Development Bank Estimation of Infrastructure Needs in 2017

The Asian Development Bank (ADB) presented their estimates in 2017 on the infrastructure investment needs for all of ADB's 45 developing member countries for 2016–2030. The total infrastructure investment need for a country over the next 15 years is the sum of new investment needs plus maintenance and rehabilitation costs across different sectors and years.

Developing Asia's investment needs will reach $22,551 billion or $1,503 billion a year. This is equivalent to 5.1% of the region's forecasted gross domestic product (GDP). The projections show that East Asia—mainly the People's Republic of China—will account for more than 60% of the required investments given its high levels of GDP and population, as well as its enormous existing infrastructure, which requires significant maintenance and rehabilitation.

South Asia follows, with infrastructure investment needs projected at $5,477 billion, or 24% of developing Asia's total. The investment needs amount to 7.6% of the subregion's projected GDP, significantly higher than East Asia's 4.5% and the developing Asia average. This is mainly due to South Asia's current lower GDP and expected faster GDP growth. Southeast Asia, Central Asia, and the Pacific w ill account for 12%, 2%, and 0.2% of the total investment needs, respectively. Investments are expected to account for relatively larger shares of GDP in Central Asia and the Pacific than in Southeast Asia.

Source: Asian Development Bank. 2017. *Meeting Asia's Infrastructure Needs*. https://www.adb.org/publications/asia-infrastructure-needs.

Emerging countries and developing countries have chronically suffered from inadequate infrastructure, and most funds are allocated for green field projects, meaning newly-developed projects. However, in these countries, the private sector is not technically and financially capable enough to develop infrastructure, which requires financial and technical assistance from developed countries, like Japan, and international financial institutions, such as the World Bank and ADB. The categories include countries in various situations throughout Asia, the Middle East, Latin America, and Africa. Their development status and demand for infrastructure should be quite varied. Such regional variations should be considered when infrastructure projects are planned.

On the other hand, developed countries' economies have grown to a higher level, which has raised the quality standard for infrastructure development. Rehabilitating and maintaining existing infrastructure is also needed in those countries. Privatization is prevalent in the markets for operation and maintenance of infrastructure, and opportunities for private companies to participate in the markets have increased. Mergers and acquisitions (M&A) among private infrastructure operators have increased in the markets for responding to such increasing needs.

Table 7.6 summarizes the characteristics of infrastructure markets in newly emerging and developing countries and developed countries. Note that "developed countries" include high-income countries while "newly emerging and developing countries" include higher and lower middle-income countries and low-income countries.

7.2.2 Contents and Underlying Risks in International Infrastructure Business

7.2.2.1 Contents of International Infrastructure Business

International infrastructure business is considered as profit-making for which a private company has its discretion and responsibility for proposing, planning, designing, constructing, operating, and maintaining an infrastructure facility. The contents are divided into the following three.

(i) **Project formation, study, and plans.** At this stage, individual infrastructure projects are proposed, and their development plans are made. Private companies are to identify needs through dialogue with developing countries' governments, to propose infrastructure projects, and to undertake feasibility studies of those projects.

Table 7.6: Characteristics of Infrastructure Markets in Newly Emerging/Developing Countries

	Emerging/Developing Countries	Developed Countries
Target Sector	• First, sectors related to fundamental life are targeted, such as water, basic roads for accessing fundamental education, and medical facilities • Second, sectors related to industrial promotion are targeted, such as electricity, roads, rails, ports, and industrial parks • In developing bypass roads or rehabilitating existing infrastructure, important infrastructure such as high-speed rails and expressways are targeted	• Number of newly built projects is decreasing • Efforts to rehabilitate and maintain existing infrastructure are increasing • In rehabilitation or replacement of existing infrastructure, advanced technology is often introduced such as magnetic levitation train • Smart community tools such as smart grid and energy management systems are introduced to reduce greenhouse gases and improve quality of life
Project Type	• Majority of funds are allocated for green field projects especially in sectors related to fundamental life and industry	• Rehabilitation and maintenance of existing infrastructure are needed • Operation/maintenance of infrastructure, privatization has become prevalent • Opportunities for private companies to participate in the markets have increased
Business Scheme	• Financial and technical assistance from developed countries are required, like international financial institutes such as the World Bank and the ADB	• Private companies are involved in the form of PPP/PFI or concession contracts • Mergers and acquisitions among private infrastructure operators have increased in the global markets

PFI = private finance initiatives, PPP = public–private partnerships.

In Japan, construction consulting companies; trading companies; companies of operating public utilities like power, gas, railways, and roads; and waterworks bureaus of local authorities are main players at this stage. They also participate in this stage as ODA experts and to develop their own business coverages.

However, consulting companies from Japan participate relatively less actively than those companies from European countries. European companies are often equipped with strong technical expertise in specific sectors like water supply and railways, and are able to foster close relationships with client countries to propose potential projects. For example, under a project of waterworks and sewerage in Saudi Arabia, Veolia Water and Suez Environment, private infrastructure operating companies in France, won a management contract with the country's public waterworks and sewerage agency. They provided guidance on management skills and training to local operators and workers. Later, the firms participated in the project under a concession agreement.

Japan has also promoted the participation of private companies in formulating and planning projects in frameworks offered by the Ministries of Economy, Trade, and Industry and of Land, Infrastructure, Transport, and Tourism as well as JICA. Central governments or regional governments are key players for infrastructure development. Hence, it is effective for Japanese private companies to start supporting the client countries' governments on planning projects in accordance with the government-to-government framework. A typical procedure is as follows: (i) conclusion of a Letter of Intent between governments, (ii) commencement of joint works among concerned working groups, (iii) formulation of a master plan or action plan, (iv) designing a yen loan project, and (v) acceptance of orders related to the project to Japanese companies.

For example, when formulating the Master Plan for Establishing a Metropolitan Priority Area for Investment and Industry in Jabodetabek Area, several Japanese construction consultants and private operators of infrastructure facilities proposed 20 projects of urban railway, roads, international ports, international airports, sewerage, thermal power plants, and smart community facilities. As a result, the selected Japanese companies were involved in the subsequent feasibility studies and implementation of some of the proposed projects.

(ii) **Engineering, procurement, and construction.** At this stage, concerned governments and related agencies or private operators make orders to private companies for engineering infrastructure, procuring materials and facilities, and constructing the infrastructure, which is called engineering, procurement, and construction, or EPC. EPC operation is generally executed by engineering companies, construction companies, and trading companies, or international consortiums. A consortium is an organization several private companies establish together for a project. It is usually formulated for the purpose of procuring techniques of another company, sharing risks, raising funds from governments, and letting local companies participate in the projects.

When construction work is carried out in other countries, it is often effective to develop partnerships with local companies who are familiar with their country and region to fill the information gaps on the local situations. Owners of those companies likely have key people in the region and may know how to manage issues during the project implementation. However, their technical and financial capacities tend to be limited, so their capability must be examined carefully prior to the project commencement.

In Asia, Japanese companies or European companies often become primary contractors and local companies oversee subcontractors. Recently, companies from the PRC and the Republic of Korea have won contracts as primary contractors due to their low bid prices, which makes recent markets competitive.

At this stage, Japanese companies must be aware of gaps between needs of client countries and technical specifications of infrastructure that Japanese companies propose, because they often propose technical specifications beyond the client countries' needs. In addition, those companies face a problem that their total cost exceeds the client country's budget. For responding to local companies' needs, they are required to reduce their costs by expansion of local production of infrastructure related materials and machineries.

Accommodating international standardization is one critical issue. Standards of European countries tend to be employed in new markets in emerging countries. For example, in the railway sector of India, the Europe-led Reliability, Availability, Maintainability, Safety[10] is employed. At present, Japanese companies must accommodate locally required technical specifications as well as the Europe-led standards that have been prevalent. It is essential to take the initiative on technical standards for promoting their infrastructure business.

(iii) **Operation and management.** There is another type of infrastructure business where a company obtains a concession for implementing a project or operating infrastructure services through a bid and earns revenues under the concession to pay back their advance investment. This type is called operation and management concession.

---

10 These are international standards determined by the International Electrotechnical Commission.

Some Japanese trading companies and electricity and power companies have participated in the operation and management of related infrastructure overseas since the 1990s. However, in general, Japanese companies are less actively involved than European companies in overseas infrastructure business.

Infrastructure operators are responsible for operating and maintaining the infrastructure. In Europe, private operators have actively expanded their business internationally. In the railway sector, privatization proceeded in the 1980s, and those operators were actively involved in the operation of railway services over the region and expanded their business outside the European Union’s coverage, such as in Asia. In water supply projects, major water supply operators, including French companies like Veolia Water and Suez Environment, have expanded the water supply business internationally. On the other hand, except in the power sector, few Japanese companies have been engaged in the operation and maintenance of infrastructure business overseas. In recent years, private operators of railways, roads, airports, and water service agencies of local governments have been showing interest in overseas operations.

It is critical that companies participating in the operation and maintenance of infrastructure services internationally take measures against various risks more than they do in domestic projects. There are a variety of risks for consideration, related to demand forecasts, cost overrun on operation, force majeure, and political aspects. The client country and private operators hold difficult negotiations on the allocation of those risks.

Recently, the client country and those operators share relevant risks reasonably by utilizing new payment methods such as availability payment, where commissions are determined based on the operators’ performance in operating and maintaining the infrastructure. For example, in the project Intercity Express Programme, the Hitachi Corporation won the bid to produce 86 items of rolling stock for high-speed railways and maintain the infrastructure for 27.5 years for the Department for Transport. The operator is responsible for producing and leasing rolling stock and maintaining the infrastructure but does not take any risk for demand. The project introduces the availability payment system, where the operator’s maintenance services are assessed by users of rolling stock, and all deficiencies are fixed and maintained to determine commissions to pay to the operator. Normally, the operation and maintenance of infrastructure is contracted for several years, which requires sharing risks appropriately among public and private agents for enhancing private operators' incentives to participate in infrastructure business internationally by introducing new schemes.

7.2.2.2 Risks Unique to International Business

Infrastructure projects involve various risks. Companies engaging in infrastructure business internationally should be aware of risks unique to the business. Below are the major risks requiring attention when promoting infrastructure business internationally.

(i) **Foreign exchange risk.** Risks related to fluctuations and transactions of foreign exchanges are one kind of risk affecting the implementation of infrastructure projects, which are caused by client countries and their governmental agencies or their institutional systems as well as the international exchange market.

Currency fluctuations and foreign exchange transactions involve a risk where a financial institution of the country controls the transaction of foreign currencies, which may affect the operator's exchange from the client country's local currency to foreign currencies and remittances. Income sources from infrastructure business are fees to be paid when using railway services and toll roads, which are earned in the local market in the local currency. On the other hand, funds to be invested in projects are often made in foreign currencies, such as Japanese yen or US dollars, and the operators convert the project's income to those currencies for allotting among their stockholders or repaying their loans. Such transactions often require permission from a financial institution of the client country; otherwise, a problem could disrupt the project's implementation.

Another risk related to transactions of foreign currencies is a risk in which private operators experience loss at the exchange between the local currency and the operator's domestic currency, mainly because of fluctuations of exchange rates in the currency market. The market is influenced by international economic environments as well as economic situations of the client country and is sometimes intervened in by the country's financial institutions. Particularly in developing countries, there is limited availability of measures controlling the risk,

Box 7.6: Asian Development Bank Risk Guarantee Mechanisms

The Asian Development Bank (ADB) offers two primary guarantee products—a political risk guarantee and a credit—both designed to mitigate risk exposure of financing partners.

Political risk guarantee covers political risk and is designed to facilitate cofinancing by providing financing partners with coverage against specifically defined political (or sovereign) risks. ADB's political risk guarantee (PRG) is primarily designed to facilitate private sector development, either through public or private sector projects. PRGs are well suited where commercial lenders are prepared to accept commercial (or credit) risks of a project, but not the political risks. Risks covered include transfer restriction, expropriation, political violence, contract disputes, and non-honoring of a sovereign obligation or guarantee.

Partial credit guarantees (PCGs) to lenders are of most forms of debt. These include commercial bank loans, loans made by shareholders, loans guaranteed by shareholders or third parties, capital market debt instruments, bonds, financial leases, letters of credit, promissory notes, and bills of exchange. A PCG covers nonpayment by the borrower or issuer (for any reason) on the guaranteed portion of the principal and interest due. This guarantee product is principally applied to financial services and capital markets (e.g., banking, leasing, insurance, and funds) and infrastructure (e.g., power, transportation, water supply and waste treatment, and telecommunications). ADB may consider other sectors on a case-by-case basis. Partial credit guarantees can be applied to loans or other debt instruments issued by private and public sector projects (limited recourse financings), public–private partnerships, corporates, as well as (sub)sovereign entities.

Source: Asian Development Bank. *Private Sector (Nonsovereign) Financing: Guarantees.* https://www.adb.org/site/private-sector-financing/commercial-cofinancing/guarantees.

such as "future dealings," which guarantee the deals at a price for future transactions. The risk should be carefully examined when constructing infrastructure of a large price and procuring associated equipment and facilities.

(ii) **Institutional risk.** Infrastructure projects are controlled by the government and its agencies in a client country. There are some risks affecting projects to be continued due to unexpected amendments in laws and regulations of the client countries, though some projects could be protected by those laws and regulations.

Developing countries still need to strengthen institutional aspects related to implementing infrastructure projects, especially on laws, accounting, finance, foreign currency, insurance, payment and settlement, and registration. Further, laws could be amended during project implementation. There are a variety of laws related to infrastructure projects, such as corporate law, labor law, immigration law, laws related to corporate tax and customs duty, laws related to private finance initiatives (PFI) and public–private partnerships (PPP), and laws on environmental protection, which are still under way and often amended. Such amendments are involved due to changes in the national strategies. If already secured and stated in the original contract, the amendments would not affect the project's implementation, but this is not necessarily guaranteed.

There is an example of the Sakhalin II Project, aiming at producing and exporting oil and natural gas reserved along the Sakhalin Coast in the Russian Federation. The project was established by a consortium of Royal Dutch Shell, Mitsui Corporation, and Mitsubishi Corporation. The Russian Federation approved the feasibility study in March 1993 and the Sakhalin Energy Investment Company (Sakhalin Energy) was formed in April 1994 to implement the project.[11] However, due to rises in petroleum prices in the world, the government of the Russian Federation changed its energy policy and designated some fields of oil and natural gas including the Sakhalin II as their national strategic mining area, which would restrict investments in foreign currencies. After the change, the government of the Russian Federation and the above three companies held discussions and concluded these changes in the allocation of the consortium's shares: the Russian national gas corporation, Gazprom, owned a 50%-plus-one-additional share of the Sakhalin Energy Investment Company Ltd. and the rest were owned by the abovementioned three companies. The change allowed the consortium to continue the project.

(iii) **Political risk.** In major infrastructure projects, the government or its agencies of a client country could be a partner to a contract. In developing countries, there is a risk of that party violating the project contract, disrupting the project implementation. The risks could be various: they don't secure enough budget to perform responsibilities stated in the contract, or their parliament or population opposes the project. Further, that the government could change and the new government could change policies for implementing the project. Sometimes the new government would not allow resumption of the project

[11] Offshore Technology. *Sakhalin II—A Timeline*. https://www.offshore-technology.com/projects/sakhalin-ii-a-timeline/

or would not perform its responsibilities stipulated in the original contract.

A typical case is the project of constructing the third terminal of the Ninoy Aquino International Airport in Manila, the capital of Philippines, which was totally affected by changes in the government. The project was a Japan-led overseas infrastructure business, where Japanese consulting companies drew up a design plan of the terminal, Japanese construction companies were engaged in civil works, and Japanese private sponsors financed the project's consortium. Different from the first and second terminals, operated by the Manila International Airport Authority, the third terminal was originally planned to be operated by a private company for 25 years through a build–operate–transport (BOT) scheme. In 2002, the original target year to start the operation, the construction had made good progress of 98% of the total work. However, a part of the terminal was eventually opened in 2008, six years later, and the full operation, including international flights, commenced in 2014.

The major reason for the significant delay was changes in political directions due to the change of the national government. The project contract between the consortium and the national government, represented by President Estrada, was invalidated by President Arroyo, who took over after the ousting of the former president. When the government's change was not carried out peacefully, the former government's decisions were sometimes not honored by the new government, and rather could be overturned. Finally, based on the Supreme Court's decision and applicable laws, the Presidential Task Force on the Ninoy Aquino International Airport Terminal 3 (Executive Order 732 on 9 June 2008) was mandated to ensure the immediate opening and operation of Terminal 3.

When the private sector is involved in an airport terminal construction project, it is a critical issue to be assured to operate in the concerned region exclusively. The consortium for the project was guaranteed under the original concessional agreement with the exclusive entitlement to operate international flight services. However, the entitlement was no longer effective under the new government, because a new BOT project was planned to expand the existing Clark International Airport, located in Metropolitan Manila. This was considered as the government's breach of the contract.

7.3 Recent Trends in International Infrastructure Business

7.3.1 Implementation Body: Engagement of Private Sector

In Japan, public authorities and public enterprises often construct, operate, and maintain infrastructure projects, as those infrastructure systems have characteristics of public interest and natural monopoly. Other countries have been formulating models of supplying infrastructure services utilizing private sector capacity to manage the services and their technical and financial resources; this is called a public–private partnership (PPP). The engagement of the private sector started in European countries and has become prevalent globally.

Box 7.7: Indonesia Case

Indonesia has the world's largest geothermal resources, by far. Muara Laboh Geothermal Power Project in Indonesia, under construction, will help the government advance toward its renewable energy and climate change mitigation goals.

The project will develop geothermal steam resources through production and injection facilities in the concession area and construct, operate, and maintain a single power generation unit with a total capacity of approximately 80 megawatts. The project will be developed and implemented under a 30-year power purchase agreement with Perusahaan Listrik Negara (PLN, the Indonesian state-owned electricity utility and the off-taker) and a 20-year support from the Ministry of Finance, as stipulated under a business viability guarantee letter.

The project is co-financed, including Asian Development Bank assistance of a $70 million loan; a $20 million parallel loan funded through Leading Asia's Private Sector Infrastructure Fund; and a $19.25 million loan from the Clean Technology Fund (CTF).

The financing needs are well beyond what any one party could bring. Through CTF concessional financing, developers are motivated to complete more challenging exploration programs and reach financial close. CTF takes a higher level of risk to allow projects to happen that might otherwise not happen. So, mobilizing that financing can help get projects off the ground, prove the resources, make them possible, and then they become somewhat more attractive to the market, enabling more private sector investment in the geothermal sector.

Source: Asian Development Bank. 2018. *Project Result/Case Study: Indonesia: Muara Laboh Geothermal Power.* https://www.adb.org/results/indonesia-muara-laboh-geothermal-power.

Box 7.8: Afghanistan Case

Poverty is Afghanistan's most challenging problem and the most critical constraint on its economic development. Most people find themselves in a poverty trap not earning enough to accumulate capital to start the investment and accumulation cycle needed to improve their living conditions. Businesses hesitate to invest in potentially productive areas because major investments, which may not be feasible, are needed.

The Rural Business Support Project in Afghanistan launched in 2006. The Project Steering Committee was established, including representatives from the Ministry of Finance; Ministry of Rural Rehabilitation and Development; Ministry of Agriculture, Irrigation, and Livestock; and civil society organizations. The project was financed by an $18.5 million grant from the Asian Development Bank and the Japan Fund for Poverty Reduction and aims to increase farm incomes in the project area by enabling farmers, agri-processors, and traders to engage in profitable production, processing, and marketing industries along selected value chains.

The project built more than 2,000 potato and onion storage facilities and financed machinery upgrades at processing facilities. The structures, made of stone or brick, are designed to reduce damage from weather and pests. The underground structures maintain a steady temperature and humidity and require no power to operate. Under the project, the farmers were able to store their vegetables for 3–5 months with losses of only about 2%.

The project stemmed from knowledge of Afghanistan and the experience that significant economic development, including job creation, can be stimulated by the type of value-added processing planned through this project.

Source: Asian Development Bank. 2016. *Project Result/Case Study: Afghanistan: A Simple Solution for Farmers.* https://www.adb.org/results/afghanistan-simple-solution-farmers.

Particularly in Asia, the primary region for Japan to promote overseas infrastructure business, several infrastructure businesses requiring technical and financial capacities of the private sector have been implemented since around 1990. Economies where the private sector has actively participated in projects of construction, operation, and maintenance of infrastructure are the PRC; the Republic of Korea; Taipei,China; Philippines; Viet Nam; Thailand; Malaysia; Indonesia; and India.

Reasons for such active participation are by the private sector (i) the demand for infrastructure could not be accommodated with public money alone and would need the private sector's finance; (ii) experienced private sector technical knowledge and management know-how related to infrastructure construction and operation are appreciated

Box 7.9: Thailand Case

Thailand is one of the biggest energy consumers in Southeast Asia, and the government is leading the way in the region in the use of renewable energy.

The Thailand Solar Power Project was in line with the strategy for Thailand 2007–2011, which focused on the three core strategic areas of infrastructure, environmental sustainability, and capital markets. It also demonstrated a larger role for the private sector in infrastructure financing through public–private partnerships.

The Asian Development Bank (ADB) played a lead role in providing long-term debt and attracting local commercial financing for the project to reach financial close. ADB assisted in obtaining long-term financing and helped the project register and pre-finance certified emission reductions under the Clean Development Mechanism, which attracted several local lending partners, including Bangkok Bank, Kasikornbank, and Siam Commercial Bank.

On 22 December 2011, the solar farm began feeding power to 70,000 households. The project has demonstrated successful operations. By replacing fossil fuels, the plant will avoid the release of more than 1.3 million tons of greenhouse gases into the atmosphere over the course of 25 years.

ADB's participation and assistance was critical for reducing the perceived risks of solar power in the industry's early development stage. Long-term financing is essential for renewable energy projects to reduce asset-liability mismatches and better amortize the high upfront costs associated with renewable energy.

As the first large-scale solar power plant in the country and the largest in Asia, the project has demonstrated the feasibility of large, private sector solar farms.

Source: Asian Development Bank. *Project Result/Case Study: Sun, Partnerships Power Thailand Solar Project.* https://www.adb.org/results/sun-partnerships-power-thailand-solar-project

for improving the efficiency of the entire operation; (iii) during the Asian financial crisis, major international financial institutions like the International Monetary Fund, the World Bank, and ADB required countries to open infrastructure markets when providing their financial aid to the countries, and (iv) enterprises of infrastructure operation in European countries and Australia promoted their operation in Asia utilizing their experiences and know-how on PPP and PFI schemes.

For example, the government of Australia has introduced PPP schemes in the domestic infrastructure markets. Private companies have executed the construction, operation, and maintenance of infrastructure projects using techniques and know-how developed outside, and their capacities have been strengthened. Those companies have been participating in infrastructure business in the world, including Asia.

The Australian government has engaged private companies in constructing, operating, and maintaining infrastructure like the Sydney Harbor Tunnel since the 1980s. In the 1990s, many related legal systems were promulgated, including the Airport Act, Road Traffic Act, the National Railway Corporation Act, and the Telecommunications Act, which increased opportunities for private companies' participation in infrastructure markets. Foreign companies can participate in the markets, and their participation has been active. For example, the project purifying sea water by a PPP in Victoria state was implemented by a consortium composed of Suez Environment (a French company), Thiess Pty Ltd. (an Australian construction company), and Macquarie Bank (an Australian major investment bank). The Itochu Corporation, a Japanese trading company, has also invested in the project and participated in the consortium.

Australian companies with experience in the implementation of domestic PPP projects have participated in overseas infrastructure business in Asia and other countries. Macquarie Bank has invested in PPP-based infrastructure development projects in the world, such as Thames Water in the United Kingdom and the United States' privatizing the international airport in Puerto Rico, utilizing know-how obtained from their experiences in PPP infrastructure business within the country.

7.3.2 Implementation Body: Emergence of Multi-Utility Service Enterprises

Major international infrastructure enterprises are competent to work in the entire process from planning a project to designing, construction, operation and maintenance, and financing management, which could be a vertical integration of the entire value chain and enable those enterprises to get involved in the entire management of infrastructure business.

Recently, there has been another type of enterprise able to cover several infrastructure sectors, such as the France-based Veolia Water Company and German-based RWE and E.ON. Those enterprises provide services combining several utility services, such as power, gas, water supply, and waste services. Such a complex service provision is called multi-utility. Those enterprises accumulate know-how that is common among infrastructure sectors. They develop a large-scale comprehensive business model covering several infrastructure sectors in some countries and gain great influence on those countries.

One such enterprise is RWE in Germany. RWE's service coverage extends widely, including power, gas, water supply, and energy transactions. The core business has remained electricity services since its foundation, and the enterprise takes care of all the procedures, generation, transmission, distribution, and sales. The enterprise was originally a conglomerate covering a wider range of businesses, including chemicals, waste management, machinery and plants, construction, and telecommunications, but it withdrew from the telecommunication sector after the market liberalization and handed over projects in the sectors of chemicals and construction. Afterwards, through the M&A schemes, it expanded its business coverage related to utility services. The enterprise's strategy was to concentrate on the sectors of power, gas, and water supply as its new core business areas and strengthen the capacity in managing the sectors' services. The major service areas are the states of North Rhine-Westphalia and Rhineland-Palatinate, major industrial areas in Germany, and RWE has been extending its business in the United Kingdom, North America, and Central Europe through establishing M&A partnerships. One example of how to expand the business areas is to buy out an operator in a country that provides total services in a utility service sector, such as Transgas in the Czech Republic, which offers total services of gas (storage, transportation, distribution, and sales) throughout the country. The buyout is often intended to acquire influence over the target market.

7.3.3 Implementation Procedure: Attracting Brownfield Projects

A project developing an infrastructure facility from zero is called a "greenfield" project. Another providing investments for rehabilitation or offering operation or maintenance is a "brownfield" project. Both names are likened to development of golf courses. The name "greenfield" is related to green courses that are newly-developed, and "brownfield" relates to the condition where the courses are damaged.

Recent international infrastructure business, particularly PPP business involving the participation of public and private sectors, is mainly in brownfield projects. Major reasons are that those projects are for operating and maintaining existing infrastructure and there is no risk related to construction work, and that we could expect stable income flows from the operation and maintenance. This business has been developed in developed counties where most of major infrastructure has been constructed, and in recent years, has been promoted in newly emerging countries and developing countries.

European enterprises have been actively involved in the PPP-based infrastructure business, and one of the examples is a road operator in Spain. The country has advanced in the engagement of the private sector in construction, operation, and maintenance of roads. At present, about 20% of the nationwide road networks are toll roads, and private road operators are transferred the right to operate the roads from the country or administrative states or localities. In Francoist Spain, the country could not receive any assistance from the financial frameworks based on the Marshall Plan for its recovery from World War II, and the national budget was chronically lacking for constructing and rehabilitating road networks. Hence, the government of Spain introduced a concessional scheme where private companies would obtain a right to earn income from collecting tolls from road users when constructing and operating toll roads with their own funds. The construction and rehabilitation of roads was mainly carried out by construction companies that had established a road operating company for operating and maintaining the constructed or rehabilitated roads. Markets operating and maintaining roads have been expanded, and the road service industry can be considered as one independent industry. Recently, concessional schemes have been employed for brownfield projects of rehabilitating aging roads and operating and maintaining those roads after rehabilitation.

Spanish road operators' capacities have been strengthened through experiencing various projects not only inside the country but also in other European countries following the market liberalization in the European Union. Now, those operators have become global road operators outside Europe. One major company is the Abertis Infraestructuras, S.A, which manages the business for approximately 60% of the toll roads in Spain and is the largest road operator. The company has been involved in road operation projects in eight countries including France, Brazil, Chile, and Puerto Rico, and plans to expand their coverage in North America soon.

7.4 Japan's Strategy to Increase Participation in Infrastructure Projects

It is necessary for Japan to formulate robust overseas infrastructure development strategies in consideration of recent changing environments around infrastructure markets, such as decreases in domestic markets, rapid globalization, and rapid growth of emerging countries, particularly Asian countries.

The government established an infrastructure system export strategy for responding to needs for infrastructure development from other countries, mainly newly emerging countries. The development of infrastructure projects outside the country will contribute to the construction, operation, and maintenance of infrastructure utilizing the domestic companies' outstanding experiences and know-how, which eventually contributes to the sustainable growth of Japanese associated industries. The below presents two perspectives for developing infrastructure projects overseas, mainly focusing on utilizing experiences in Japan.

7.4.1 Practical Use of Institutional Designs and Strategies for Infrastructure Associated Business

To make international infrastructure business sustainable, it is essential to make the business profitable. The core of infrastructure business is generally considered as the process of hard infrastructure (design, procurement, construction, and operation and maintenance), but we should be aware of soft aspects of the concerned infrastructure, such as institutional designs for operation and associated business. Combining hard and soft aspects of the concerned infrastructure could enhance the efficiency and profitability of the infrastructure business, which eventually make the entire business sustainable.

Japan's infrastructure business has evolved over the years. A variety of institutional designs and business schemes have been applied to develop associated projects and facilities to make better use of the infrastructure. These experiences may be useful to share with other countries.

In the case of a railway project, it may not always be profitable if revenues are expected to come from charging passengers. However, it is possible to make the railway project profitable overall by combining other related industries, such as real estate and retail distribution. As discussed in Chapter 6, there are typical cases: complex development of railway and real estate along the Den-en-toshi Line by the Tōkyū Group and promotion of the Suica/Ekinaka business by the East Japan Railway Company.

Further, it is essential to design the overall institutional structure to enable business development. For example, when promoting the complex development of railway projects and real estate projects, Japan has recommended the development along the railway line to be built following the Act on Special Measures concerning Comprehensive Advancement of Housing Development and Railway Construction in Metropolitan Areas. The act enables entities to convert land along a new railway line through a land readjustment project and carry out the railway project and the residential land development project together. The act has been applied to the development of the areas along the Tsukuba Express in the Tokyo metropolitan area (Kurosaki and Ogura 2013).

The land readjustment approach has progressed along high-speed railways, particularly areas around the railway stations. One successful case applying this approach was Sakudaira Station along the Hokuriku Shinkansen. Around the station, a new town was established, where station squares, cultural theaters, community spaces, commercial and industrial facilities, hotels, and residential areas were located. The approach was applied for Honjō Waseda Station of the Jōetsu Shinkansen as well and has been recognized as an effective scheme to develop areas around high-speed railway stations.

Table 7.7 summarizes examples of employing institutional designs and strategies for infrastructure associated business in the railway sector. JICA's technical assistance schemes may be effective to help developing countries with institutional designs, while the consultancy service could help infrastructure operators to make good use of infrastructure. Experiences and lessons on combining hard and soft aspects of infrastructure eventually expedite the export of infrastructure systems.

Table 7.7: Examples of Employing Institutional Designs and Strategies for Infrastructure Associated Business in the Railway Sector

	Emerging/Developing Countries	Developed Countries
Urban development in collaboration with railway development (Transfer of development value to transport firms)	• Formation of landowners' union	Den-en-toshi Line by Tokyu Group
	• Integral Housing and Railway Act • Advanced land readjustment scheme	Tsukuba Express
	• Framework that required surrounding land owners to pay the cost of railway construction • Subsidy for private company's railway construction	Minato Mirai Line (MM Line)
Efficient utilization of district surrounding the station	• Special floor area ratio	Restoration of Tokyo Station building
	• Inter-city bus terminal • Adjoined station building	Renewal of Shinjuku Station
Practical use of unused railway land	• Practical use of freight yard site • Land readjustment scheme	Redevelopment of Shiodome area Redevelopment of Takamatsu Port Yard site

continued on next page

Table 7.7 *continued*

	Emerging/Developing Countries	Developed Countries
Urban development of area surrounding high-speed rail station	• Development of sub-core of the city • Development of facilities for attracting passengers	Shin-Yokohama Station (Tōkaidō Shinkansen)
	• Beneficiary payment principle • Donation • Urban facility development next to the station	Kakegawa Station (Tōkaidō Shinkansen)
	• Land readjustment scheme • Station square development	Sakudaira Station (Hokuriku Shinkansen)
	• Beneficiary payment principle • Donation	Honjō-Waseda Station (Jōetsu Shinkansen)
Industry promotion Tourist promotion	• Relocation of the head office • Relocation of the factory	Toyama Prefecture Ishikawa Prefecture
	• Cooperation between international airport and shinkansen • Tourism promotion	Tōkaidō Shinkansen and the Golden Route for Inbound Tourism
	• Branding • Tourism promotion in broader area	South Kyūshū area along Kyūshū Shinkansen
	• High level cancer treatment center • Attracting patients both in local area and in broader area	South Kyūshū area along Kyūshū Shinkansen

Source: Mitsubishi Research Institute, Inc.

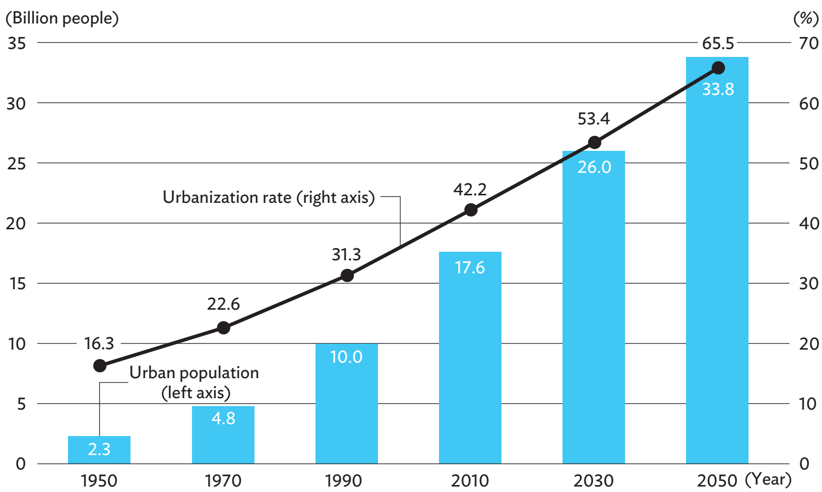
7.4.2 Export of Urban Infrastructure Systems Utilizing Experiences

The comprehensive development of urban infrastructure systems could be another attractive area, utilizing experiences in Japan. Urban areas are supported by a wide range of infrastructure in several sectors, such as transportation, energy, water, water and sewerage, environment, information and telecommunications, and disaster management, which are closely interrelated. It could be effective for enhancing the country's international competitiveness against European countries, the US, the PRC, and the Republic of Korea if this infrastructure is combined as a packaged urban system to export. The comprehensive approach could view the entire value chain process from the stage of project formulation, study, planning, design, procurement, and completion, until operation and maintenance.

There are three reasons it is worthwhile to promote the comprehensive development of urban systems. The first is increases in needs for strengthening urban functions and redeveloping or expanding urban areas in newly emerging countries and developing countries due to their rapid economic growth. Particularly, demands for urban infrastructure have been significantly increasing in Asian countries where urbanization has progressed rapidly, like the PRC, ASEAN, and India. Figure 7.5 shows the trend of urbanization in Asia overall. Taking India as an example, there were 43 cities having a population over one million in 2010, but there will be 68 such cities in 2030, out of which 6 will be megacities of more than 10 million. The urban infrastructure system here includes transportation (roads, railways, airports, and ports), energy (power generation, transmission, and distribution, and smart community), water supply and sewerage, recycling and waste management, information and telecommunications, and disaster management, which have been increasingly demanded in newly emerging countries to improve.

Second, the urban infrastructure system is composed of several interlinked factors. Agents are also varied, including construction consultants, manufacturers, engineering companies, general

Figure 7.5: Urban Population and Urban Population Rate in Asia



Note: Urbanization rate is the ratio of urban population to total population

Source: United Nations. 2009. *World Urbanization Prospects, 2009 Revision*. New York.

Box 7.10: Housing in the People's Republic of China

The transformation in the urban housing system of the People's Republic of China (PRC) over the last 3 decades is the result of the PRC's economic restructuring and the urbanization process. The changes in the housing system have contributed strongly to reshaping the mode of urbanization.

The PRC's urban housing system has shifted rapidly from a state-dominated system to one in which market-like mechanisms play growing roles in the production and consumption of urban housing. The PRC's market-oriented reforms of housing provision also spurred the drastic transformations of spatial landscapes in the cities. With urban residents' increased access to housing from the market rather than from work units, their labor mobility patterns, job–housing links, and transport modes and commuting behavior have all greatly changed.

The great housing market boom in the PRC is not only a consequence but also a source of the PRC's great leap forward in urbanization in the new century. In short, the changing functions of state intervention in the PRC's housing sector have yielded far-reaching impacts on the mode of urbanization.

Source: Chen, J. 2016. Housing System and Urbanization in the People's Republic of China. ADBI Working Paper 602. Tokyo: Asian Development Bank Institute. https://www.adb.org/sites/default/files/publication/201926/adbi-wp602.pdf

construction companies, trading companies, and operators. When developing urban infrastructure systems, it could be essential for those agents to establish partnerships with the central or local governments of a client country to seek their understanding of the entire proposal and make the proper evaluation. That could help Japanese companies to win the international competition.

Third, we could make good use of the experiences and advantages of Japan thus far. Since the high economic growth period in the 1960s, urbanization progressed rapidly with the movement of population and industries from rural areas. In the course of this, Japan has faced issues most countries would experience in their growth process, such as air and water pollution, environment and energy problems, traffic congestion, and an aging society. To resolve those issues, the country has been developing technical systems and institutional designs. Further, there are various good examples of attracting urban developers overseas, such as development of new towns in suburban areas, redevelopment of old towns, including the development of the Marunouchi area, central Tokyo, and Tokyo Midtown in Roppongi. These experiences are Japan's advantages and are worth sharing overseas. Table 7.8 summarizes Japan's experiences with urban systems.

Table 7.8: Japanese Experiences on Urban Systems

Sector	Item	Technology and Systems in Japan
Transport	Urban rail	Mutual direct operation, automatic train control, centralized traffic control, IC card, shopping area inside train stations
	Road	Intelligent transport systems, electronic toll collection systems, self-driving
	Parking	Minato Mirai Line (MM Line)
Efficient utilization of district surrounding the station	Electricity	Eco-cute, combined cycle power generation, energy management system
	Gas	Ene-farm, combined heat and power, emergency gas dissipation system
	Energy saving	Zero emissions building/house, energy saving ICT facilities, top runner program
Water	Water and sanitation	Water leak detection system, water treatment system, recycled wastewater system, direct water
Information and Telecommunications	Information	Cloud network, optical fiber, big data management
	Telecommunications	Digital terrestrial
	Air pollution	Flue gas desulfurization system, flue gas denitration system, volatile organic compound treatment apparatus
	Noise and vibration	Soundproof wall, vibration-free method
	Heat island	Water-retentive pavement, rooftop greening
	Garbage disposal	Waste disposal, power generation using a fluid bed gasifying and melting furnace, recycling system
Housing	Sprawl	Complex building, high-rise apartments downtown
	Aging society	Elderly housing with supportive services, renovation of existing residential areas

continued on next page

Table 7.8 *continued*

Sector	Item	Technology and Systems in Japan
Disaster Prevention	Earthquake disaster	Seismic isolation, vibration control method, earthquake early warning system, emergency care system, disaster prevention centers, business continuity plan
	Urban flood	Underground dam, predictive analysis system of urban floods
	Fire	Fireproof material, fire extinguishing systems, urban planning
	Lightning	Uninterruptible power system (UPS), constant voltage constant frequency (CVCF)
Crime Prevention	Urban crime	TV monitoring system, biometrics (fingerprint-, iris-, vein- authentication)
	Terrorism	Joint training, terrorism information network, emergency video transmission system
Urban Development	Inner city problems	Compact city, urban residential comprehensive design scheme
	Urban development scheme	Land readjustment scheme, special floor area ratio, chain type urban renewal
	Underground shopping area	Earthquake resistance standards, evaluation of seismic capacity, evacuation guidelines

Source: Mitsubishi Research Institute, Inc.

7.5 Case Studies

This section details cases of Japanese companies that responded to demands from clients and got engaged in the infrastructure business overseas utilizing experiences and practices in Japan.

7.5.1 Sydney Harbor Tunnel, Australia

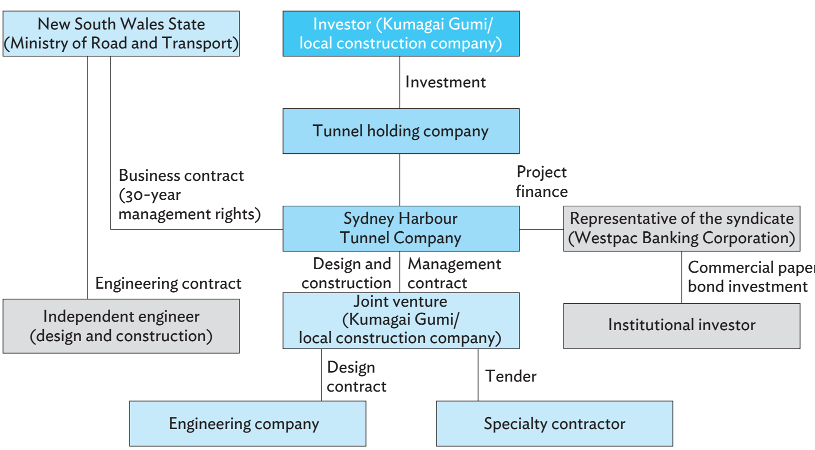
Australia is a country with varied experiences and knowledge on PPP schemes for the construction, operation, and maintenance of infrastructure. The country welcomes foreign and domestic companies to the PPP market, which provides opportunities for Japanese companies to participate in the market.

One prominent infrastructure project in which Japanese companies were involved was a project of constructing the Sydney Harbor Tunnel. The tunnel was built to mitigate traffic congestion along the Sydney Harbor Bridge connecting the northern part of Sydney and its commercial district. The harbor tunnel was 2,280 meters long with four-lane roads and was constructed by the sunken tube method, connecting eight reinforced concrete boxes and started operation in 1992. To construct and operate the tunnel, the build–own–operate–transfer (BOOT) scheme was employed, and Kumagai Gumi took the responsibility as a primary investor, engineer, and constructor of the entire consortium (Figure 7.6).

The New South Wales state government also participated in the consortium as a sponsor and selected the consortium. Kumagai Gumi established a joint venture with a local construction company, Sydney Harbour Tunnel Co., Limited, and their share of the joint venture company's stakes was 50:50. The company had an agreement with the state government for 35 years: 5 years for construction and 30 years for operation. According to the agreement, the company would operate the tunnel until 2022, and the entire ownership would be transferred to the state government.

One reason why the joint venture was selected was Kumagai Gumi's outstanding technical capacity including a box-type construction method for long underwater tunnels. The project was an early stage PPP project in Australia, and the government took most of the major risks, one of which was the demand risk. The government guaranteed minimum toll revenue

Figure 7.6: Business Scheme of Sydney Harbor Tunnel (Australia)



Source: Kumagai Gumi.

to the joint venture company. The joint venture company took mainly risks related to civil works completion. These added up to preferable conditions for Kumagai Gumi to engage in a PPP project.

Prior to the Sydney Harbor Tunnel project, Kumagai Gumi participated in several harbor tunnel projects overseas, including a BOT undersea tunnel project in Hong Kong, China. In addition, the company has developed new business models in brownfield projects, such as the Eastern Harbor Tunnel project in Hong Kong, China, in which the company was involved in the operation and maintenance of the tunnel.

7.5.2 Export of Shinkansen to Taipei,China

For the development and improvement of infrastructure in developed economies, more innovative and updated technologies are preferred. Japan has promoted infrastructure development with such technologies; the typical example is the export of shinkansen. The first project of exporting Japanese shinkansen was in Taipei,China.

The high-speed rail project connects Taipei, located in the north, and Kaohsiung, located in the south, and runs the distance of 340 km in 90 minutes. The population of Taipei,China is 23.5 million (2016) and its population density is 653 per km^2. About 90% of the total population live in the western corridor of Taipei,China, i.e., along the rail, so many passengers were expected. A BOT scheme was employed in the project, where the company financed on its own, obtained the operation rights for a certain period after completion, and will return the facility to the government of Taipei,China. The project was the largest BOT infrastructure project in the world.

There were various difficulties in the entire process from bidding to contract awarding due to international bidding systems, though eventually Japanese original technologies were employed. In 1996, the bidding was done, and two domestic companies competed: the High Speed Rail Union in Taipei,China, which collaborated with European companies, and China High Speed Rail Union, which collaborated with a group of Japanese companies including Mitsui Corporation, Mitsubishi Heavy Industries, Toshiba, Kawasaki Heavy Industries, Mitsubishi Corporation, Marubeni Corporation, and Sumitomo Corporation. At the beginning, due to the lower-cost proposal, the High Speed Rail Union won the bid. However, the government's decision changed after 101 people died in an accident on the German high-speed railway, InterCity Express, and the 1999 Jiji earthquake struck. The government selected the Japanese group as the technical partner of the High Speed Rail Union, probably because the group proposed introducing early earthquake detection and warning devices.

The complication in the bidding process eventually caused changes in the entire system, resulting in many complicated situations. Japanese systems were not employed in the entire railway system, as the operation styles followed the European ones. Eventually, mixed systems were developed and became operational, where the rolling stocks produced in Japan were operated using French operation methods and passed German-made turnouts and crossings.

The standardization also involved difficulties. Even after the technical partner of the High Speed Rail Union was changed to the Japanese group, all the technical specifications were based on the European railway standards as the European railway consultants had originally proposed. Hence, the Japanese group needed the consultants' guidance on changes in its proposal in accordance with the European standards and receipts of certification for the group's products. That required significant costs for producing documents to verify the safety of the shinkansen for operation.

The high-speed rail project in Taipei,China, considered as one successful case of Japan's overseas infrastructure development, provided an opportunity to experience various challenges involved in the bidding procedure, complication in the mixed systems, and the customization of technical systems to the European standards. Lessons learned from the experience should be noted in the next development stage. At present,

Box 7.11: High Speed Rail in Taipei,China

The high-speed rail project started construction in 2000 with the total length of 350 kilometers and was put into revenue service in 2007, running from Nangang to Zuoying with 12 stations and 5 maintenance depots. The operation performance has been outstanding.

The high-speed rail keeps improving its self-maintenance ability for solving different types of problems from facilities or components to ensure reliable operation. A safety assurance culture has been established through robust mechanisms and independent safety appraisal. Taipei,China has various natural hazards, so a disaster warning system has been set up to detect potential hazards. A series of valuable countermeasures has also been developed. Due to ridership and revenue beyond expectations in the initial period of operation, financial reform was conducted with the assistance of the government. After the success of the financial reform, the high-speed rail corporation applied for an initial public offering (IPO), and the revenue will gradually grow in the coming years. The high speed rail project has thus reached a healthy and sustainable status.

Source: Chen, J. 2018. Planning, Implementing, and Operating High Speed Railway (HSR) in Asia Seminar. 15 March. Tokyo: Asian Development Bank Institute.

several countries' governments have been considering implementing high-speed railways, for example, the lines of Dallas–Houston in the US, Ahmedabad–Mumbai in India, and Singapore–Kuala Lumpur, Malaysia.

7.5.3 Development of Maintenance Business in the United States

Maintenance business in developed countries should be worth consideration, as the deterioration of existing infrastructure has been attracting public concern in those countries. In the US, the deterioration has been more serious than in Japan. In the case of roads, an increase in gasoline taxes would contribute to a financial source for maintenance, management, and renovation. According to the American Society of Civil Engineers, the total amount needed for work on deteriorating infrastructure could be estimated at $1.6 trillion from 2013 to 2020.

Out of those, the maintenance and management of bridges attached to roads could be one area for maintenance business. In 2007, the structure and deck of a steel truss arch bridge on a highway in Minneapolis, Minnesota, collapsed, attracting public concern about the maintenance and management of road bridges. The following introduces a case of West Nippon Expressway Company Limited, which has been involved in the growing market.

The company has worked to improve the efficiency of investigation by checking cracks using high-resolution digital images and identifying exfoliated parts using infrared cameras. It expects potential needs in the US, where many roads are aging, and has been involved in investigations in the country. First, the company conducted a test on existing bridges in Florida and the performance was well acknowledged. Afterwards, the company established a local affiliate company with a 100% share and sold their techniques to local road operators and engineering companies in the country. They won contracts for road inspections in the states of Florida and Indiana.

West Nippon Expressway Company Limited's strategy to do business on techniques of inspecting bridges in the US was in line with the country's policies. In the US, aging roads and bridges were considered critical earlier than in Japan, and in the 1970s, the National Bridge Inspection Standards were enacted, requiring biennial inspection of bridges. However, the data obtained in the inspections were from visual observations, which limited the maintenance and management of bridges and associated items such as utility lines, which were inspected because future forecasts of conditions and performance of bridges were impossible.

Inspection of continuous bridges at sea. West Nippon Company Limited efficiently investigates structures using digital and infrared cameras (photo by West Nippon Expressway Company Limited).

The United States Department of Transportation developed a research and development program, the Long-Term Bridge Performance Program, to develop a model to forecast and evaluate quantitative performance of bridges based on the assessment of their deterioration. The company was involved in the program and introduced their work of enhancing the efficiency of road inspection in Japan. It followed the national policies and sought possibilities to promote the company's well-developed technical knowledge on road inspection in the country.

There are several cases where Japanese companies have participated in the infrastructure business in the US. Though it had quality techniques for inspecting bridges, West Nippon Expressway Company Limited faced various difficulties when starting the business in unknown business fields. It had to understand the country's unique business customs, network with local agents for developing business channels, and convince those agents about the company's technical advantages and uniqueness in the local language. Further, as the US emphasizes experience, the company had to conduct pilot projects on its own and prove their successful implementation for earning trust from their potential clients, road operators. In the end, the company won 16 contracts on road and bridge inspection work in the country, mainly in states on the east coast, such as Florida, Pennsylvania, Indiana, Maryland, Virginia, and New York.

Moreover, the company's techniques developed for inspecting bridges have been employed for other types of concrete structures, and it has expanded its business area to subways such as the Washington Metro and hydropower dams like the Itaipu Dam in Brazil. Now, techniques for operating and maintaining roads that were developed from practices originally used on highways in Japan have been utilized overseas.

Bibliography

Section 7.1

Todaro, M. P. and S. C. Smith. 2015. *Economic Development, 12th Ed.* Boston: Pearson Education.

World Bank. 1993. *The East Asian Miracle: Economic Growth and Public Policy*. A World Bank policy research report. New York: Oxford University Press.

Section 7.2

Asian Development Bank and Asian Development Bank Institute. 2009. *Infrastructure for a Seamless Asia*. Tokyo: Asian Development Bank Institute.

Kurosaki, F. and M. Ogura. 2013. Construction of Tsukuba Express and Urban Development Based on the Integrated Development Law. Selected proceedings for 13th World Conference on Transport Research.

Offshore Technology. Sakhalin II—A Timeline. https://www.offshore-technology.com/projects/sakhalin-ii-a-timeline/

Organisation for Economic Co-operation and Development. 2006. *Infrastructure to 2030: Telecom, Land Transport, Water and Electricity*. Paris: OECD.

Organisation for Economic Co-operation and Development. 2012. *Strategic Transport Infrastructure Needs to 2030*. Paris: OECD.

US Department of Transportation Federal Highway Administration. 2007. Case Studies of Transportation Public–Private Partnerships around the World.

Afterword

Chul Ju Kim,[1] K. E. Seetha Ram, and Kai Xu[2]

This book reviewed the implementation of infrastructure and assessed the existing and emerging development challenges of countries. Infrastructure will remain a key priority to promote social and economic development. Sustainable infrastructure will be central to achieving global commitments to address climate change and strengthen disaster risk management. Infrastructure also helps to meet the growing needs of high-quality education, health, and other social services; address emerging challenges like aging; and develop skills to adapt to new technologies. Policy makers will sustain the efforts to eradicate extreme poverty and expand the vision to achieve prosperous, inclusive, resilient, and sustainable infrastructure development. Attention should be paid to the integration of expertise across sectors and themes to address more complex development challenges.

Challenge 1: The Investment of Infrastructure

Infrastructure plays a vital role in economic growth and social development. It is important to look at the "bigger picture" of the supply of and demand for capital for infrastructure. Globally, infrastructure investment requirements are enormous, and particularly so in developing economies.

Taking the historical infrastructure spending as a starting point, about 3.8% of world gross domestic product (GDP) has been spent on economic infrastructure over the last 20 years, i.e., around $2.4 trillion per year (applied to the 2010 GDP). In the future, McKinsey estimates that total infrastructure financing as a share of GDP will need to be around 5.6% by 2020 worldwide. In terms of the investment composition, the World Bank estimated annual infrastructure spending in developing countries in 2008 at $800 billion–$900 billion, of which $600 billion–$650 billion was from the public sector, $50 billion–$100 billion from official development assistance, and $138 billion from private participation in infrastructure. Relative to GDP, this spending share was 4.2% globally; 6.8% in the East Asia and the Pacific region; 4.2% in South Asia; 7.1% in sub-Saharan Africa; 6.9%

1 Chul Ju Kim, deputy dean at the Asian Development Bank Institute, was a guest contributor to this English version of the book.

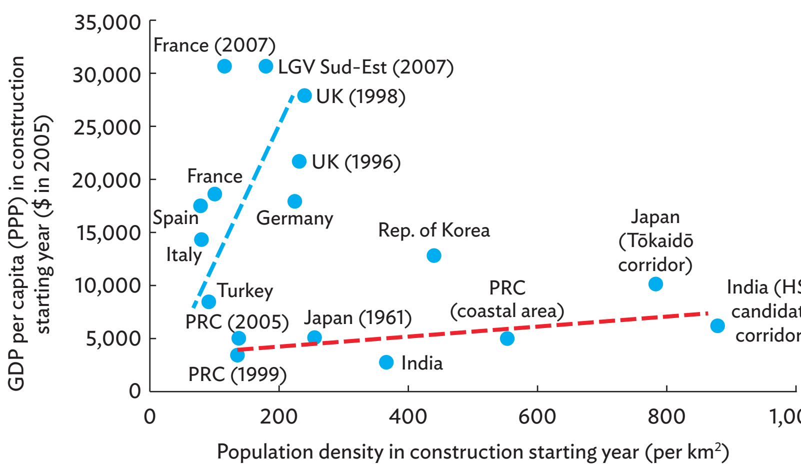
2 Kai Xu, a doctoral student at the University of Tokyo, was a guest contributor to this English version of the book.

in the Middle East and North Africa; and 1.2% in Latin America, Europe, and Central Asia. However, many countries are held back by chronic underinvestment in infrastructure and poor maintenance of existing infrastructure. The scale of investment requirements for sustainable infrastructure calls for a strengthening of finance from all sources and a reorientation towards long-term and affordable infrastructure.

Challenge 2: Prioritizing the Key Infrastructure

Studies suggest that priority of investment in specific infrastructure helps balancing the trade-offs between the huge infrastructure demand and the scarce finance sources. This is particularly true for the developing countries. Some infrastructure projects might provide the expected positive stimulus, yet with a relatively high rate of return from infrastructure investment. Evidence from around the world shows that the social returns from investing in sanitation, transport, and energy infrastructure greatly exceed those from other forms of capital investment. Studies in several developing Asian countries illustrate how infrastructure, particularly roads and sanitation, helps to reduce poverty.

Transportation infrastructure is widely deemed to have critical development impacts. Improving and expanding transportation infrastructure is believed to be synonymous with economic development. Take the development of high-speed rail (HSR) for an example. As shown in the following graph, in terms of the relationship



GDP = gross domestic product, HSR = high-speed rail, km² = square kilometer, PPP = purchasing power parity, PRC = People's Republic of China, UK = United Kingdom.

Source: Institution for Transport Policy Studies (2012).

between population density and GDP per capita in the commencing year of HSR, we can clearly divide the implementations into two groups. For European countries and the United States, higher GDP stimulated the start of HSR (the blue line), while for Asian countries, a large population density is needed for the justification of the huge HSR investment (the red line).

The implication can be drawn from the study for nations without HSR. As India is perfectly located on the line, the implementation of HSR is the priority.

Challenge 3: Capturing the Spillover Effect

Infrastructure investment has been widely believed to be an effective tool to boost and promote the efficiency of a country's economy, which largely comes from its spillover effects on wider society. The spillover effect is defined as an economic impact in one region that occurs because of seemingly unrelated events in other regions. The spillover effects of infrastructure are usually far bigger than the actual investment in infrastructure. In addition to the direct effect from infrastructure investment itself, the impact through marginal increases in productivity of capital and labor, better proximity to markets, and lower costs also greatly contribute to the regional or neighboring economic growth.

In recent years there has been an increasing move toward allowing for impacts beyond the direct user benefits and costs in the appraisal of infrastructure investments. There has been increasing interest in the wider economic and social impacts, as well as environmental and other externalities, such as the restructuring and rebalancing of local and regional economies through structural change and the relocation of activities. New infrastructure generates positive spillover effects, which can be captured and returned to the investor to increase the rate of return. It is hoped that this evidence will help policy makers obtain a better grasp of the full potential impact of infrastructure investment.

Challenge 4: Opening Infrastructure Finance Sources

Besides the capture of spillover effect as a potential finance instrument, it is necessary to consider other infrastructure finance sources, such as the supply of private capital and innovative investment vehicles.

Public capital from central, regional, local, and other government institutions' budgets is the dominant means of financing infrastructure. To mobilize more domestic resources, governments should strengthen their revenue collection and expenditure management systems, as well as the transparency and management of their debt to ensure debt sustainability in coordination with other development partners. Although continuing to plan and provide most infrastructure in the long term, national government sources alone may not be sufficient to bridge the infrastructure gap.

Since the early 2000s, private infrastructure finance has assumed a more important role in the form of project finance, bonds, and public–private partnership (PPP) procurement methods. As well as serving as an additional source of capital, private management of infrastructure also increases efficiency, improves productivity, and eliminates high-risk lifecycle costs for the state. Developing, structuring, and preparing bankable PPP projects will help create more opportunities for private sector investment and participation.

Multilateral development banks (MDBs) and national development banks have a special role in supporting infrastructure in emerging markets and developing countries, from the policies and institutions that can translate promising ideas into real demand, all the way through to finance at a manageable cost of capital and the effective management of risk. The MDBs and national development banks are vital in the early stages of these projects to get over the policy and institutional issues and the most difficult risks. If these stages are well-managed, large private sector funds can come in. International development agencies are also an important source of loans, grants, financial services, and technical assistance for infrastructure projects. In 2013, the Japan International Cooperation Agency's global development assistance comprised loan aid (72%), technical cooperation (17%), and grant aid (11%).

Infrastructure is a capital-intensive group of assets requiring long-term planning and operating as part of networked supply chains in noncompetitive market conditions. In order to unlock the capital needed for sustainable infrastructure, policies that leverage the strengths of various finance sources are needed.

Challenge 5: Climate Change and Disasters

Climate change and disasters threaten the long-term sustainability of development in the region. Over recent decades, the world has experienced a significant increase in the number, intensity, and impact of extreme weather events such as tropical cyclones, floods, droughts, and heat waves. Serious disasters including earthquakes and tsunamis have also caused significant loss of lives. Growing climate change and disasters pose challenges to economic growth and exacerbate existing vulnerabilities.

Rapidly scaling up climate- and disaster-resilient infrastructure is key to sustainable development and inclusive economic growth.

In order to improve climate and disaster resilience, measures will include risk-sensitive land use management, integrated flood risk management, climate- and disaster-resilient infrastructure design, the diversification of livelihoods to factor in long-term climate change, and the strengthening of early warning systems. Disaster and climate risk should be factored into the design and location of all infrastructure—during initial screening of investment proposals, site selection, detailed feasibility and design phases, economic analysis, and subsequent monitoring and evaluation. In the long term, flexible design features are required, reflecting the dynamic nature of disaster risk and potential climate change, and to ensure continued resilience throughout the intended life of an investment.

Governments should scale up their support for climate change and disaster mitigation by prioritizing and incentivizing mitigation investments for implementing sustainable strategies.

Challenge 6: Innovation and Technology

Infrastructure has always been important to nations' economic growth, but the infrastructure needed for today's economy is rapidly changing with advances in information and communications technology. Technological innovations constantly provide us with more ways to connect with people, goods, services, and opportunities. This can affect the infrastructure demand, redefine how we use and interact with the infrastructure around us, or even lead to an entirely new infrastructure system.

One important use of technology will be to integrate with our existing infrastructure, enabling us to make the best use of what we already have. Managing our infrastructure systems in a smarter way could reduce the need to construct new assets. Instead, technology can increase the effective capacity of our infrastructure, reduce maintenance and operating costs, and improve reliability and safety. In infrastructure operations, advanced technologies can reduce life cycle costs and increase durability, improve the efficiency and quality of services, and minimize negative environmental and social impacts.

Emerging technologies have the potential to radically improve the way we manage our infrastructure. Governments should consider how to maximize the opportunities for technology to shape infrastructure and foster sustainable economic growth, enable infrastructure to remain competitive, and to improve quality of life. Policy makers should seek ways to promote the use of advanced technologies across infrastructure operations and provide capacity building support when necessary. Policies that enhance the regulatory environment for promoting innovative technology, such as the digital economy, expanding internet connectivity, and investing in hardware and software are essential.

Challenge 7: Domestic Capacity Building

Capacity building plays a major role in addressing these challenges, improving the effectiveness of infrastructure investment, and meeting public needs. Governance and institutional capacity stand for the ability to manage the challenges and opportunities brought by the changing environment. Many countries in the region still face governance issues, including poor public services, weak government institutions, and corruption. Capacity building for government officials can enhance their ability to address development issues and deliver projects. Strengthening the institutional capacity will connect officials, the private sector, civil society, and academia to regional and global knowledge hubs and learning centers, and will facilitate cooperation among countries within the region and beyond. Governance reforms to counter corruption and strengthen professional civil services, regulatory quality, and the rule of law are needed to sustain development momentum and to ensure that the benefits of growth are equitably and widely shared.

Standardization and reforms are needed for efficient domestic capacity building systems. Policies should help implementing agencies strengthen their capacity to plan, design, finance, and implement projects, including the application of advanced technology, reduction of life cycle costs, assurance of the financial viability of investments, and the maintenance of infrastructure assets. Technical assistance resources can be utilized based on pilot test innovative approaches and solutions in specific areas or sectors with the aim of replicating successful approaches on a larger scale. Different departments should be encouraged to generate knowledge products and services and contribute to capacity building efforts in their areas of expertise. In this way, promoting and disseminating knowledge across institutions can be achieved.

Further Reading

Asian Development Bank (ADB). 2017. *Meeting Asia's Infrastructure Needs*. Manila: ADB. https://www.adb.org/publications/asia-infrastructure-needs

ADB. 2019. *Sustaining Transit Investment in Asia's Cities: A Beneficiary-Funding and Land Value Capture Perspective*. Manila: ADB. https://www.adb.org/publications/sustaining-transit-investment-asia-cities

Asian Development Bank Institute (ADBI). 2018. *Financing Infrastructure in Asia and the Pacific: Capturing Impacts and New Sources*. Tokyo: ADBI. https://www.adb.org/publications/financing-infrastructure-asia-capturing-impacts-and-new-sources

Index

Boxes, figures, notes, and tables are indicated by b, f, n, and t following page numbers. Page numbers in italics indicate illustrations.

C

E

K

N

Q

R

Principles of Infrastructure

Case Studies and Best Practices

Infrastructure is a priority around the world for all stakeholders. Infrastructure projects can continue for several years, from planning and construction to the provision of services. As development in Asia and the Pacific accelerates, governments must invest more in infrastructure to ensure continued economic growth.

This book draws on lessons and case studies from Japan and worldwide, covering broad and long-term infrastructure projects. It describes the principles of developing quality infrastructure and focuses on the various steps of a project—from conception, design, planning, and construction to operation and management. It also discusses overseas development assistance, taking examples from Asian Development Bank and World Bank projects. This book is an important reference tool for policy makers in Asia who are planning and implementing large-scale public infrastructure.

About the Asian Development Bank Institute

ADB Institute, located in Tokyo, is the think tank of the Asian Development Bank, an international financial institution. ADBI aims to be an innovative center of excellence for the creation of rigorous, evidence-based knowledge that can be implemented as new actionable policies by developing and emerging economies, so as to contribute to achieving a prosperous, inclusive, resilient, and sustainable Asia and the Pacific. It also contributes to ADB's overall mission and operational priorities in line with ADB's Strategy 2030. This vision will lead ADBI to continue to be a globally recognized think tank.

About the Mitsubishi Research Institute

The Mitsubishi Research Institute was founded in 1970 in commemoration of the centenary of the Mitsubishi Group. MRI is creating a brighter future alongside clients, aiming to achieve the sustainable development of local communities, corporations, and society at large by functioning as a think tank that applies collective wisdom to the development of the 21st century civilization. MRI is creating a promising future by addressing the challenges of society and their clients through integrated strength of a "Think and Act Tank" committed to envisioning the ideal future while implementing the solutions that will make it a reality.

ADBIPress

ASIAN DEVELOPMENT BANK INSTITUTE
3-2-5 Kasumigaseki, Chiyoda-ku
Tokyo, 100-6008 Japan
Tel +81 3 3593 5500
www.adbi.org

ISBN 978-4-89974-107-7

9 784899 741077