CHAPTER 4

Measures for mitigation of flood hazards in Japan

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Abstract

The aim of flood control planning in Japan since 1945 has been to confine river water to within riverbanks and to ensure that levees protect river basins from flooding. In many rivers, dams were constructed in upstream areas and long levees were built along the riverbanks. The main aim of flood-control planning is to prevent the flooding of river basins by the overflow of river water across riverbanks; however, as rainfall prediction has recently become difficult because of the abnormal weather, the main emphasis of flood-control planning has shifted from prevention to providing areas of refuge. The River Law of Japan was revised once more, and artificial measures of flood control, irrigation, and environmental management, etc. were introduced in 1997. Flood hazards must be dealt with by 'hard measures' such as levees and reservoirs and 'soft measures' such as the provision of hydrological information, regulation of land use, and evacuation advice. In 2001, the Japanese Government made it mandatory for all regional bodies to compile and distribute flood-hazard maps to inform inhabitants of the danger of flooding and the locations of sites of refuge for all inhabitants. Some measures taken to mitigate flood hazards and present a number of case studies were described in this chapter. Consequently, it is important to know what is to do before, during, and after a flood according to the past flood hazards.

4.1 Introduction

Flood events have been occurring with alarming frequency all over the world; this may reflect abnormal weather. When all the different types of natural disasters are considered, more than half of the associated fatalities are due to flooding, and almost half of the overall disaster-related losses result from flooding [1].

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Rivers in Japan are generally short and steep, meaning that rainfall flows rapidly from the river system; this increases the risk of flooding. About 70% of Japanese citizens live within river basins and in coastal areas. Following World War II, the construction of dams and levees was encouraged to protect areas damaged during the war and to generate hydroelectric power; however, this resulted in destruction of the environment, and in recent years some of the levees have been breached by floodwaters.

Since the 1900s, small rivers in Japan have been reclaimed to provide extra land and serpentine rivers have resulted from river-improvement projects. Trees along rivers have been cut down and natural banks replaced by concrete ones; consequently, water quality has deteriorated and various ecosystems within river basins have been destroyed with the construction of dams intended to provide hydroelectric power, the development of water resources, and flood control in upstream areas. Fish species have lost their breeding sites and wild birds have lost important habitat areas. With the construction of dams and levees, the landscape changed over a short time period and rivers became confined to artificial channels.

Ironically, the scale of flooding has increased as flood-control measures have been implemented. Artificial channels mean that rainwater is rapidly discharged into the sea, but the flux of river water increases temporarily following rainfall. Moreover, the area of river basins has increased with ongoing river improvements and the extent of forests and fields that store water has decreased; consequently, discharge has increased. To address this problem, the heights of levees have been increased, and the development of river basins was advanced once again. This led to a further increase in discharge as the cycle repeated itself. This cycle highlights the limitations of river engineering; it is therefore necessary to change the approach taken to river improvements.

The approach toward flood control in Japan recently changed from one of containment to one of allowance. The fact that there are many rivers and mountains in Japan implies that large numbers of people live upon alluvial plains that are made up of river-deposited earth and sand. While river basins within alluvial plains must be protected by levees, it is also important to protect the environment and ensure human safety by undertaking river-improvement projects. It is therefore necessary to change our approach to disaster prevention from a complete dependence upon levees and dams. It goes without saying that we treasure the forests in upstream areas of river systems and that we must evacuate rapidly to shelters during times of flooding. We work tirelessly to find ways of dealing with floods but choose to return to the river after each flood event to commune with nature.

4.2 History of flood-control measures in Japan

The history of flood control in Japan can be subdivided into four stages as shown in Table 4.1 [2].

The first stage, prior to the Meiji Restoration in 1865, was one of symbiosis with flooding that sought to minimize flood damage associated with the flow of rivers across their banks by excluding settlements from flood-prone areas.

Table 4.1: History of flood control in Japan.

Stage (period)	Stage 1 (~1865)	Stage 2 (1865–1949)	Stage 3 (1949–2000)	Stage 4 (2000~)
Feature	Symbiosis with flooding	Productive industry. Improvement in agricultural productivity	Rapid urbanization	Mature community
Public order	Minimum of flood damages	Continuous and high river levees	Multipurpose dams (flood control, irrigation, generation of hydroelectric power)	Flood control from disaster prevention to flood mitigation
Aspect of flood damage	Standing water drained quickly from the land	Flood were frequent and floodwater receded extremely slowly	Urban flood	Flood over a standard maintenance
Population (persons)	700,000–30,000,000	30,000,000–78,000,000	78,000,000–128,000,000	128,000,000~
Law or system of Japan (year)	Nothing	Old River Law (1896)	River Law (revised) (1964) Flood Control Act (1949)	New River Law (1997) Flood Control Act (revised) (2007)

The Japanese of the Jomon Period (10,000–4000 BC) did not require the use of fertile flood-prone fields for agriculture because they were hunters; however, they began to make use of alluvial plains as farmers during the Yayoi Period (4000–3000 BC). The change to a farming lifestyle led to an increase in production capacity and a concentration of the population upon fertile floodplains. The remains of a Yayoi Period village reveal an irrigation canal around the village and the trace of a large ditch and embankment to protect the site from flooding. Paddy fields were developed on flat land alongside small rivers, and the population in Japan grew from 0.7 millions to 2.5 millions between 50 and 200 AD. Large-scale river-improvement projects were undertaken during the Kofun Period (200–600 AD) when iron tools were first developed for farming. For example, the excavation of a canal was planned by the Emperor Nintoku and an

embankment was constructed in Manda (Fig. 4.1) [3]. Legal codes established over the period 600–900 AD led to substantial river improvements: the construction of dikes, ponds, and ditches was considered the duty of provincial governors. In the Middle Ages, from the 12th to the 16th centuries, many valley ponds were constructed in hilly areas and dike-protected areas of the polder (Wajyutei) were constructed to protect a village from the Kiso, Nagara, and Ibi rivers (Figs 4.1–4.3) [4, 5].

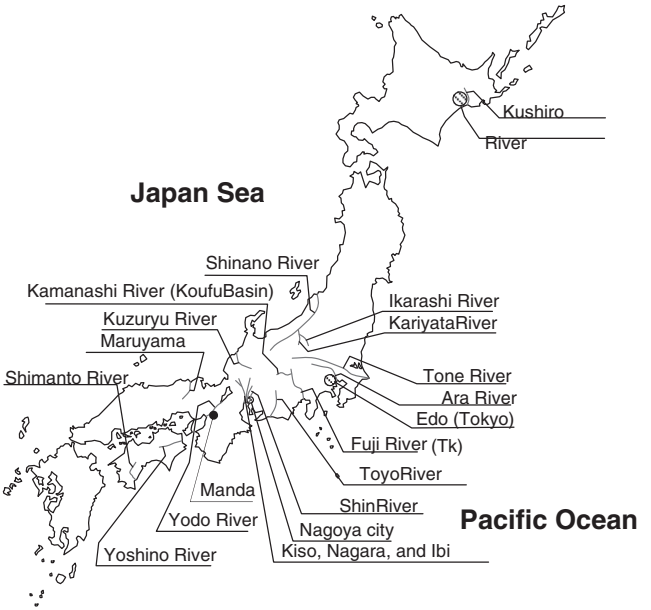

Figure 4.1: Rivers and places described in this work.

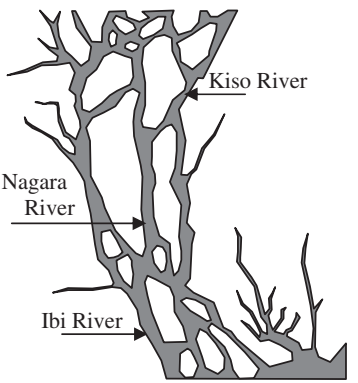

Figure 4.2: Polder area in 1600s.

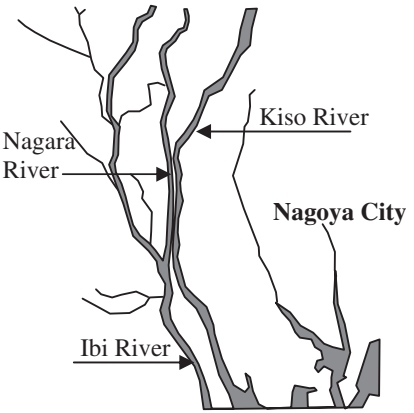

Figure 4.3: Polder area in 2000s.

The river improvements undertaken during the Warning State Period (900–1600 AD) included the construction of flood control of the Kamanashi River by General Shingen Tekeda (1521–1573 AD), who was in charge of the Kofu district (Figs 4.1 and 4.4) [6]. General Takeda protected the Kofu Basin from a succession of flood hazards by constructing one-sided levees along the Kamanashi River. These measures led to a 76% increase in the production of paddy rice during the approximately 150-year period from the Keicho Era (1596–1615 AD) to the Houreki Era (1751–1764 AD).

The improvement to the Tone River and the Ara River flowing through the Kanto Plain was initiated in 1793–1853 AD (Figs 4.1, 4.5, and 4.6) [7]. The area of farmland by restricting the area of flooding was increased and the flood-control works to transport floodwater to the Tone River and Ara River was used. Tadatsugu Ina (1550–1610), chief retainer of General Tokugawa, supervised the exploitation of the Tone River. His technique, termed the Kanto or Ina method, involved the use of natural landforms, the strengthening of natural levees, the construction of reservoirs, dispersal of the force of the flood, and protection of important sites by the construction of low-crown levees. His approach to flood control was to tolerate minor damage due to partial flooding because sediment deposited by the floodwaters provided fertilizer for agricultural land. In this way, rivers and their immediate environment were able to live close together. Consequently, the population of Japan grew from 10,000,000 to 30,000,000 during the period 1550–1700 (during the first stage of flood control in Japan), and the area under cultivation increased from 10,000 to 29,500 km^2 because paddy fields increased in size with the changes made to large river channels. The rapidly increasing population meant that in 1865 the Japanese Government adopted the policy of increasing the food supply by developing paddy fields alongside rivers; consequently, many farming people came to live in dangerous flood-prone areas.

To protect these vulnerable farmers, continuous and high river levees were constructed along large rivers located on alluvial plains. This marked the start of the

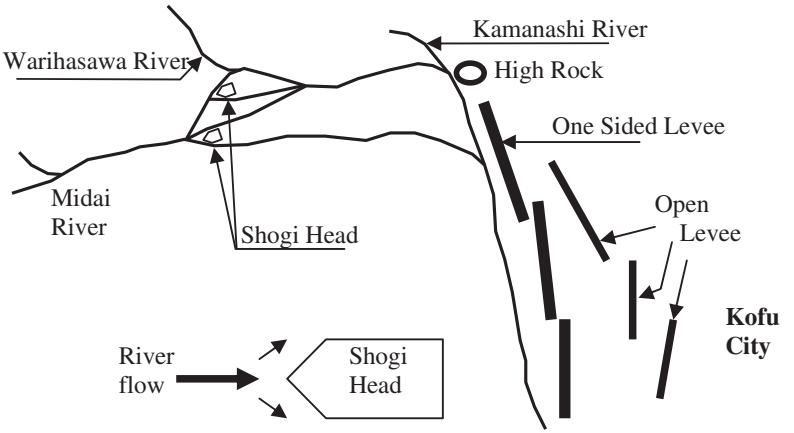

Figure 4.4: One-sided levees along Kamanashi River.

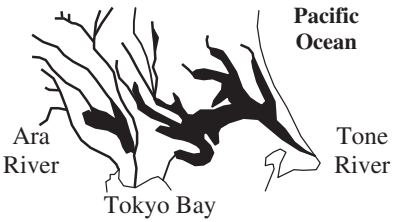

Figure 4.5: Kanto Plain in 1600s.

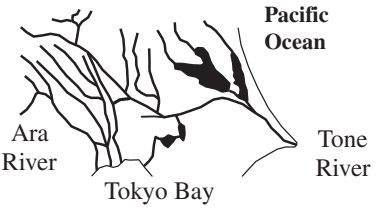

Figure 4.6: Kanto Plain in 2000s.

second stage of flood control in Japan, and from 1865 river projects were undertaken to keep floodwaters within the river channel. The policy of flood control following the Meiji Restoration (1867) was based on western ideas that became enacted in government legislation. Many foreign engineers were invited to Japan by the Meiji Government to pass on their techniques to local engineers. These foreign specialists mainly practiced techniques of river maintenance and water transportation that were developed in Europe.

In 1873, the Meiji Government passed regulations governing the repair of rivers, harbors, and roads. Under the direct control of the Meiji Government,

river-maintenance projects concerned with water-borne transportation and safety were carried out on 14 rivers, including the Yodo, Tone, and Kiso (Fig. 4.1). Projects on other rivers were carried out by the state representative of the Meiji Government. However, a succession of flood events and the change from water-borne to land-based transportation (mainly railroads) led to a change in the river policy of the Meiji Government. Following the passing of the River Law of Japan in 1896, large-scale flood-control projects were promoted by the Japanese Government. For example, improvements were made to the Kuzuryu River, the waterway of the Shinano River was partitioned, and drainage works were undertaken for the Ara River (Fig. 4.1).

Private title over rivers was ruled out by the River Law of 1896, such that all official works on rivers were integrated into the executive right of the Minister for Home Affairs, that is, the Japanese Government gained control of all the rivers in Japan. Policies on irrigation and flood control were passed during the Taisyou Era (1912–1926). The main objective of these policies was to attain improvements in agricultural productivity, that is, flood control and agriculture were two sides of the same coin. Government policy in regard to agriculture was enforced in the Irrigation Combination Acts and the Cultivated Arrangement Law. Since World War I, urbanization and industrialization in Japan has led to increasing demand for water for industrial use. This led to the serious problem of whether agriculture was to be superceded by industry in terms of the priority assigned to water use. During the first stage of flood control outlined above, flood-related standing water drained quickly from the land; in contrast, during the second stage floods were frequent and floodwater receded extremely slowly.

The third stage of flood control encompassed the period of rapid urbanization and increasing population following World War II. The River Law of Japan was revised in 1964 following increased demand for water. During the third stage, multipurpose dams were constructed with the aim of flood control, irrigation, and the generation of hydroelectric power. The river manager, who was the Minister for Rivers in the case of first-class rivers, the Governor of the Prefecture in the case of second-class rivers, and the Mayor of the local community for other classes of rivers, was defined in the River Law, which was revised in 1964. The basic plan for first-class rivers was determined by the River Council, which operated outside of the Land, Infrastructure, and Transport Ministry. The maintenance of rivers was carried out at short notice as required in terms of flood control and water use, but the harmful environmental effects of public works worsened with the passing of the revised River Law. Although flood control is important in terms of saving lives, river works quickly destroyed ecosystems that had developed over long periods of time.

In 1997, the River Law of Japan was revised once more, and artificial measures of flood control, irrigation, and environmental management, etc., were introduced [8]. Namely, the fourth stage of flood control involved a change in approach to flood control from disaster prevention to flood mitigation. Recently, societies' interest in the ecosystem has increased because of a growing awareness of environmental problems. Many ideas for valueless river-improvement projects and dam construction are proposed by the people who live within river basins, but the

way in which people think about rivers is being changed by the civil service. The main points of the 1997 River Law include the following: (1) to consider the ecosystems of wildlife, (2) to preserve water-cycle systems, and (3) to review the relation between rivers and adjacent areas. This represents a marked change in the policy position of the River Law in terms of the environment. The supposedly extraordinary events of water shortages and flooding were the prime focus of earlier versions of the River Law, but rivers are now recognized as a part of our daily life in relation to the policy toward rivers during peace times. In the future, it is important to take part in the servicing and management of rivers along with political officers and the administration should take a leadership role. People living within river basins must understand the importance of river basins from the source of the river to the estuary; people and nature must live close together.

The Flood Control Act having the object to watch for and guard against water-related disasters caused by floods or storm surges and to mitigate damage in order to maintain public safety was also established in 1949. A part of the Flood Control Act was revised to assume flood zones and make up the hazard map in 2001. Moreover, the determination of assumed flood zones and the preparation of hazard maps were obliged by the Flood Control Act revised in 2007.

4.3 Flood-hazard mitigation plan

In Japan, rivers tend to be flooded during heavy rain because of natural and social factors. In the past, Japanese planners considered that flood-control works should conform to the natural characteristics of rivers. For example, flood-control works involved crib spurs (Seigyu), gabions, stone-pitched groyns (Shogi head), etc. (Figs 4.7 and 4.8), developed by General Shingen Takeda [6].

It has been said that his works were adopted from the techniques employed for Du Jiang Yan (Figs 4.9 and 4.10) in China [6, 9, 10]. These types of works conform to the nature of the river and tie in with the surrounding environment because natural materials (wood, stone, bamboo, etc.) are used in their construction. The Du Jiang Yan was maintained by the director Hyou Lee over the period 306–251 BC. Hyou Lee developed the method of controlling flooding by deepening the riverbed and constructing a low dam. The Du Jiang Yan controlled the flooding of the Minkou (Minjiang) at a branch of the Yangtze River (Chang Jiang), which was an important source of livelihood, by controlling the depth of the riverbed and the elevation of the dam based on empirical knowledge. Instructions were set in a sutra to create a saying related to flood control: to dredge river beds, to construct levees, to lay stones as fish bill, to set tree fence, to flood by channels, to divide flow for four to six by gabions, to write the basic water level, to set a basic marker at river beds, and to have respect for the old system.

Moreover, the flood-control manual describes ways to ensure a smooth river flow by removing sandbar corners at revetment works, canceling the energy of divisional flows, and being flexible in the face of changing times and places by understanding the force of flow and other natural conditions.

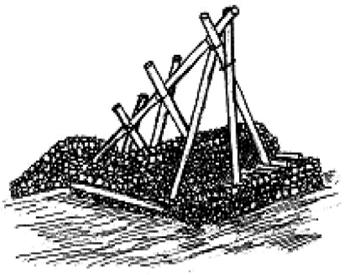

Figure 4.7: Crib spur and gabion.

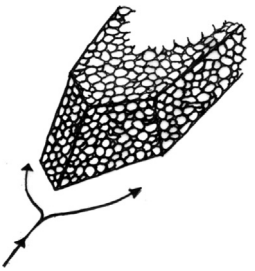

Figure 4.8: Stone-pitched groin.

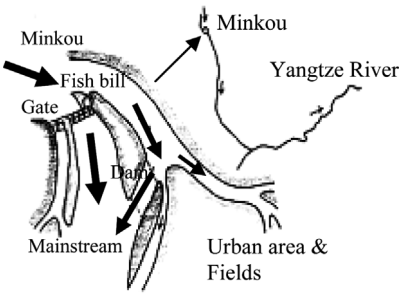

Figure 4.9: Outline of Du Jiang Yan.

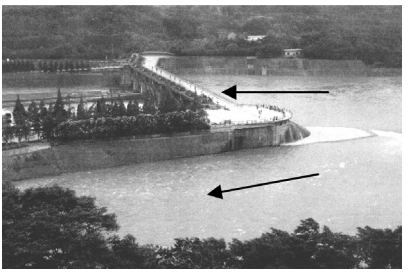

Figure 4.10: Photograph of Du Jiang Yan.

Flood-hazard mitigation involves any task that can be undertaken to minimize future economic losses and eliminate threats to public safety resulting from flood hazards. The basis of a mitigation plan is an inventory and map of all the known or predicted areas that might suffer economic damage resulting from heavy rain, extreme runoff, or flooding. Finally, a flood-hazard mitigation plan includes a prioritization of problem areas (according to pre-flood, syn-flood, and post-flood categories) and an *Action Plan* to eliminate these economic losses by undertaking a sustained effort over a long period of time [11].

The following actions can help reduce losses and minimize the risk of hazards. (1) Purchase undeveloped floodplain land to use as open spaces such as parks and forest reserves. (2) Relocate, elevate, or flood-proof homes, buildings, and structures. (3) Develop reservoirs, wetlands, and regional storm-water management facilities. (4) Rebuild roads above flood levels using expanded open-ditch drainage for water storage. (5) Build or upgrade water supplies, sanitary sewers, and storm sewers with increased capacity and water-tight connections. (6) Build levees and channel diversions around valuable, easily damaged areas. (7) For property that is easily protected, anticipate floods and deploy sandbags as early as possible. (8) Purchase flood insurance.

Recently, levees in Japan have been breached by large flood events with enormous amounts of resulting damage. Flood hazards in urban areas have been increasing every year. The development of fail-safe protection against flooding is impractical; consequently, it is necessary to reconstruct the urban area to ensure that it is resistant to flooding hazards. Large first-class rivers managed by the Japanese Government are measured on the basis of flooding every 100–200 years, but the construction of levees and dams is unable to keep pace with that required to prevent flooding. Until now, flood-control measures have focused on containing river flow with the construction of levees alongside rivers and the construction of dams across upper streams; however, recent record heavy rains and a reduction in the funds available for public works have led to new flood-control systems that seek to minimize flood hazards. For example, one residential street is protected by two lines of levees [12] constructed alongside the adjacent river. The two lines of levees are created by elevating the road and the railroad that lie between the cluster of houses and the field. The area that cannot be protected by the levees is not adversely influenced by constructing the circular structure that encloses the residential area and the field.

The National Flood Insurance Program's Community Rating System in the USA [13] encourages a review of six general mitigation strategies: (1) prevention activities that keep problems from worsening, (2) property protection is usually undertaken by property owners on a building-by-building or parcel basis, (3) emergency services measures are taken during a flood to minimize its impact, (4) structural projects are employed to keep flood waters away from a protected area, (5) natural resource protection preserves or restores natural areas or the natural functions of floodplains and watersheds, (6) public information programs advice property owners, potential property owners, and visitors of local flood hazards as well as ways in which to protect people and property.

In a White paper [14] by the Land, Infrastructure, and Transport Ministry, the Japanese Government addresses flood hazards by clearly emphasizing conservation, regeneration, the creation of a sound environment, and taking environmental responsibility, that is:

1. The conservation and formation of a healthy river environment such that the river consists of various natural environments and enjoys natural rejuvenation.
2. The recovery of water volumes in rivers such as the termination of falling sections of river.
3. The continuity of organisms and sand such as a course for fish and sand supply.
4. Reconstruction of the area between towns and rivers to encourage interaction between people and rivers.
5. Environmental education about rivers such as those activities undertaken by the River Activities Council.

4.4 Case studies

Levees of the Kariyata River and the Ikarashi River (Figs 4.1, 4.11, and 4.12) in Niigata Prefecture, Japan, which were branches of the Shinano River, gave way in 2004 during heavy rain that was part of a 300-year flood event [15, 16]. About 10,000 houses were flooded and 12 people were drowned during the flooding. A flood-control dam located upstream and levees withstood a 100-year flood in the Kariyata River. Figures 4.13 and 4.14 are plans of the Kariyata River in future. Figure 4.13 is a shortcut of river and Fig. 4.14 is a retarding basin of river. Two flood-control dams were also constructed upon the Ikarashi River; however, the

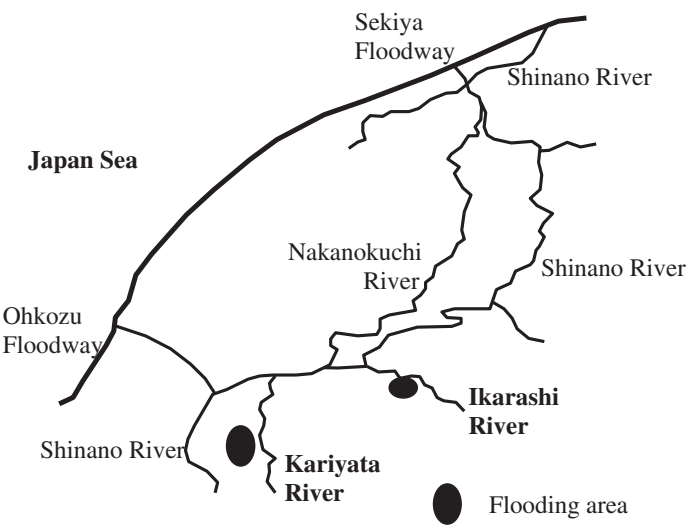

Figure 4.11: Outline of Kariyata River and Ikarashi River.

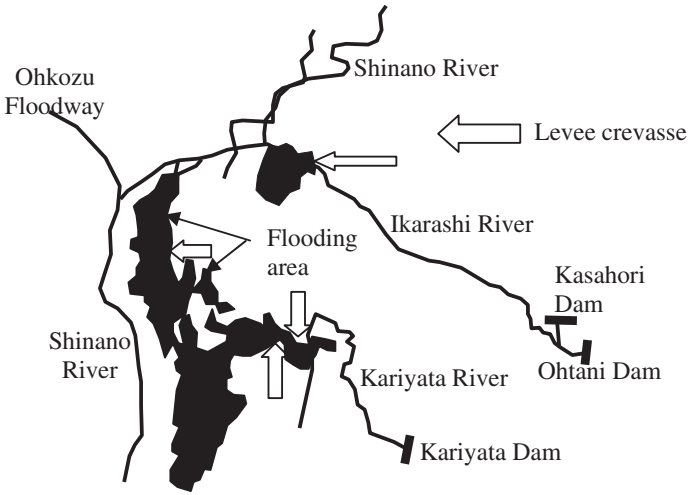

Figure 4.12: Flooding areas and levee crevasse in 2004.

Figure 4.13: Kariyata River in future (a part of shortcut).

Figure 4.14: Kariyata River in future (a retarding basin).

rainfall was higher than that expected. Following the flood, the policy of flood control in Niigata Prefecture was revised; that is, the upstream levees were constructed lower than previously and a retarding basin was planned for about 100 ha of paddy fields to ensure that water overflow across the levee was guided to the retarding basin, which is devoid of people. About 400 houses in areas of high flood risk were moved to safer areas in Ikarashi; residents in the basin of the Ikarashi River preferred to shift rather than safeguard their existing homes [16]. Figures 4.15 and 4.16 show the sketch of the Ikarashi River in future. Figure 4.15 is a shortcut and a dredging of river bed, and Fig. 4.16 is a raising of levee and a widen of river [17, 18].

The levees of the Asuwa River (Figs 4.1 and 4.17) in Fukui Prefecture, Japan, were destroyed by heavy rainfall in 2004; many houses were flooded. Approximately 60% of those injured during the flood were elderly; consequently, the government devised guidelines for supporting refugees in the case of a disaster [19, 20].

Moreover, information on flooding was revised to make it easy to understand for all readers. For an example, the difference of words between 'dangerous water levels' and 'special precaution water levels' was clearly explained. Table 4.2 is the result of questionnaire whether people along the Asuwa River have the disaster consciousness or not and hear the flood warning or the refuge notice or not [21].

The Agenda Committee of the Investigation on the Flood Hazard of the Asuwa River proposed the basic policy on the prevention of flood hazard as shown in Fig. 4.18 [21].

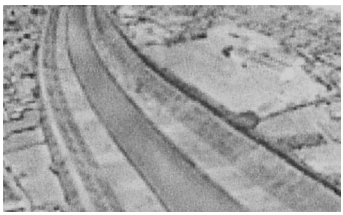

Figure 4.15: Ikarashi River in future (shortcut and dredging of river bed).

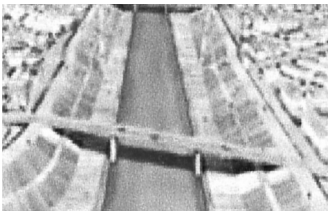

Figure 4.16: Ikarashi River in future (raising of levee and widen of river).

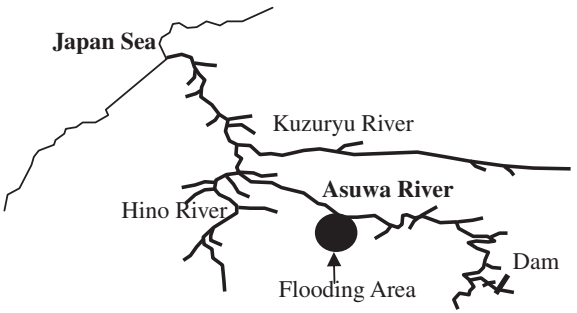

Figure 4.17: Outline of Asuwa River.

Table 4.2: Disaster consciousness and flood warning or refuge notice.

Disaster consciousness	Rates (%)	Flood warning or refuge notice	Rates (%)
Did not expect the flood	65.2	Heard before the flooding	33.6
Expected the flood	24.4	Heard just before the flooding	26.5
Sensed the hazard	10.0	Heard after the flooding	21.2
The other	0.4	Did not hear	17.4
		The other	1.3

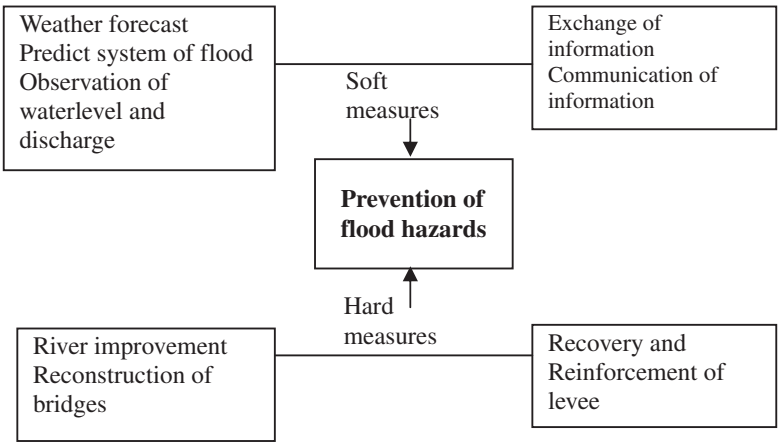

Figure 4.18: Basic policy on prevention of flood hazards.

The Shimanto River (Figs 4.1 and 4.19–4.23) in Kochi Prefecture, Japan, is known as a clear river. The upper stream contains a hydropower dam that is 80 m high; the river has a total length of 196 km. The water taken from the river for power generation is generally later discharged downstream of the dam, but some water is discharged into the Iyoki River, which has no flood risk [22].

Figure 4.19: Outline of Shimanto River and Iyoki River.

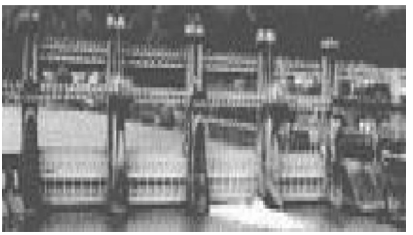

Figure 4.20: Ieji River dam.

Figure 4.21: The upper stream of the dam.

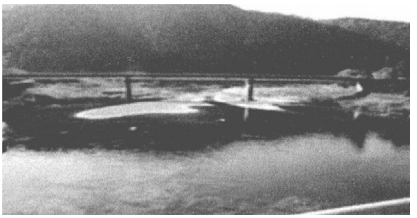

Figure 4.22: The lower stream of the dam.

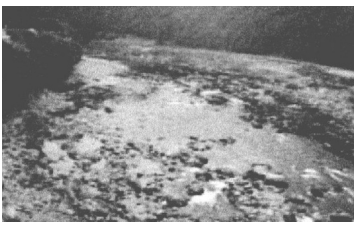

Figure 4.23: Ten kilometer lower stream from the dam.

The quantity of discharged water is 1 tonnage per second for 190 days of the year, with no water discharged for 90 days of the year for the 20 km section from the dam to a point where a large branch occurs in the river. In this section of the river, water activities and fishing are prohibited. A plant that rises from the ground was used rather than a waterside one; however, the quantity of water is still abundant in the downstream area of the Shimanto River because there are many branches of the river. The operation of the dam does result in deterioration of the quality of water and a reduction in the fish catch because 30% of the total water volume is captured by the dam. Residents and fishermen in the middle and lower reaches of the river are appealing for the dam to be opened and for the water to be returned to the river. Given that global warming is an important issue, the generation of hydroelectric power is a valuable energy source; however, the natural recovery of the river, as represented by clear river water, has an important value that exceeds the value of hydroelectric power that is generated using water taken from the river [23].

The upper reaches of the Yoshino River (Figs 4.1 and 4.24–4.27), Shikoku Island, contain 370 ha of flood-defense forest that is the largest bamboo thicket in Japan.

The force of the water that overflows from the river is mitigated by the forest, and sand is trapped by the vegetation; consequently, flooding has been reduced over the past 100 years. However, the Japanese Government has recently proposed the construction of a movable dam (Daijyu Dam) for the purpose of the river improvement. Local people are protesting that the Japanese Government is intent on destroying nature and wasting money [24–26].

A wide reservoir was constructed in Toyohashi City, in the downstream part of the Toyo River (Figs 4.1 and 4.28–4.30), Aichi Prefecture in Japan, during the Edo Period (1600–1860) [27–29]. The reservoir was surrounded by an open levee (the Kasumitei levee) as shown in Fig. 4.28 that contains gaps through which the water preferably overflows. A thick copse grows adjacent to the levees, and the reservoir is used as a field in times of normal river flow. The Japanese Government plans to construct a dam in the upper stream to remove the need for the reservoir and copse, but local people oppose this scheme [30]. The nature of flooding-related river improvements in this area has been employed since the Edo Period, although it involves the sacrifice of farmland. Low levees are planned for open levees as shown in Fig. 4.29. Figures 4.30 and 4.31 show the photographs of the flood around the diversion and open levees of the Toyo River in 2003.

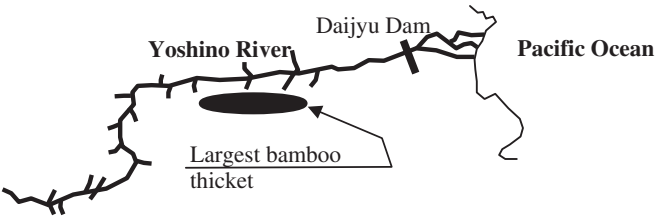

Figure 4.24: Outline of Yoshino River.

Figure 4.25: Largest bamboo thicket.

Figure 4.26: Bamboo thicket and shoaling.

Figure 4.27: The Daijyu dam.

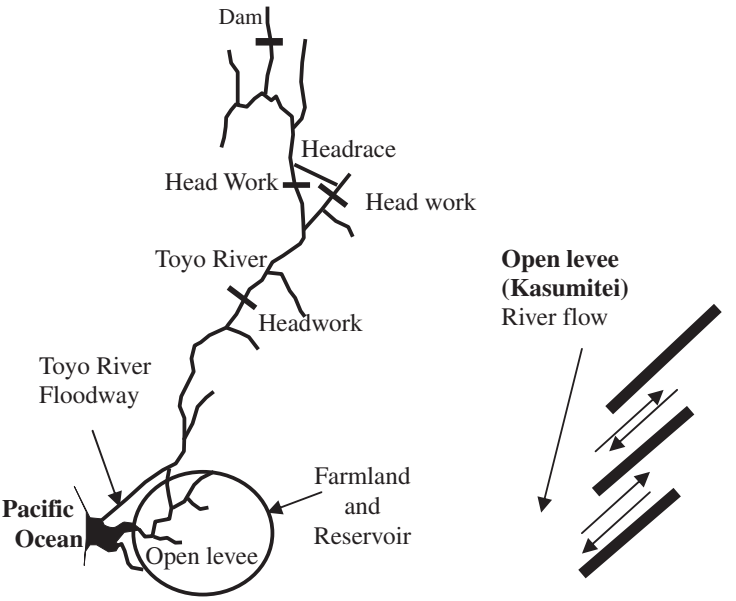

Figure 4.28: Outline of Toyo River.

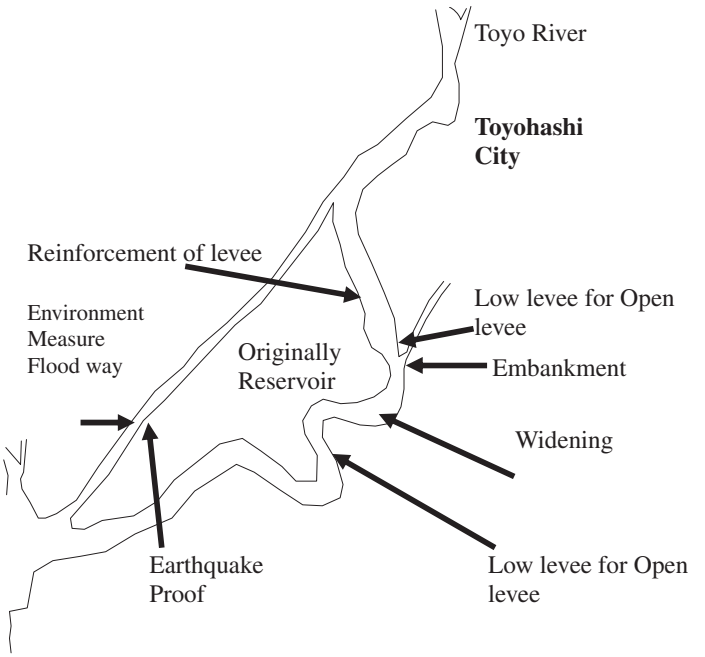

Figure 4.29: Improvement plan of Toyo River.

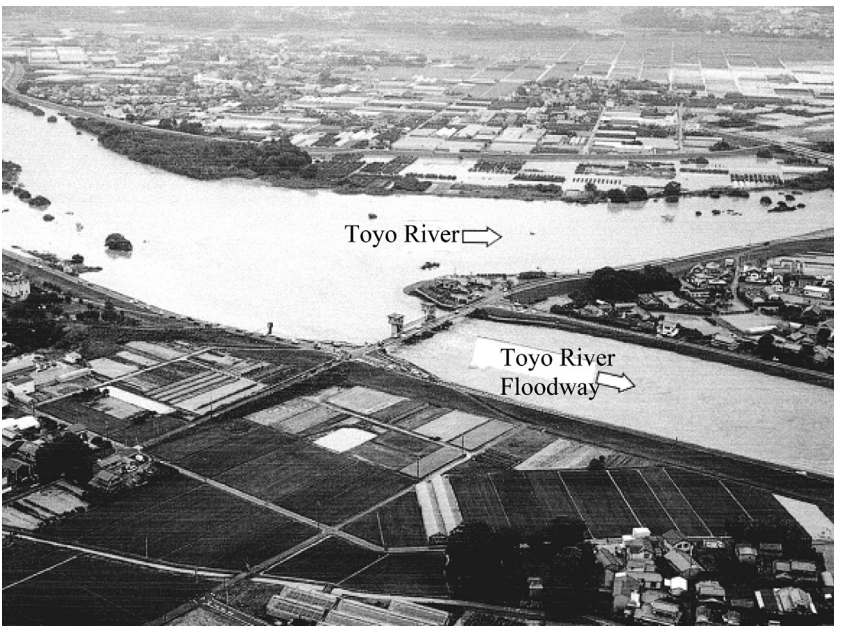

Figure 4.30: Flood of Toyo River in 2003.

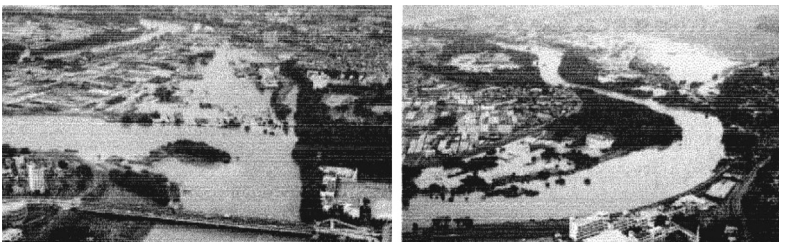

Figure 4.31: Flood around open levees of Toyo River.

Heavy rain associated with a typhoon on October 23, 2004, led to serious damage, the flooding of 11,874 households, and the inundation of 4083 ha by the Maruyama River (Figs 4.1 and 4.32–4.36), which flows through the Toyooka Basin in Hyogo Prefecture [31, 32]. Following the flood, the 'Nature Revival Plan in the Maruyama Water System' was devised in November 2005. The plan states that the recovery of nature should be compatible with river-improvement measures; that is, improvement measures largely involve the upkeep and regeneration of meadows. Residents within the river basin are proceeding with a course of action that aims to reproduce a river environment in which various creatures and people live together with the cooperation of local inhabitants.

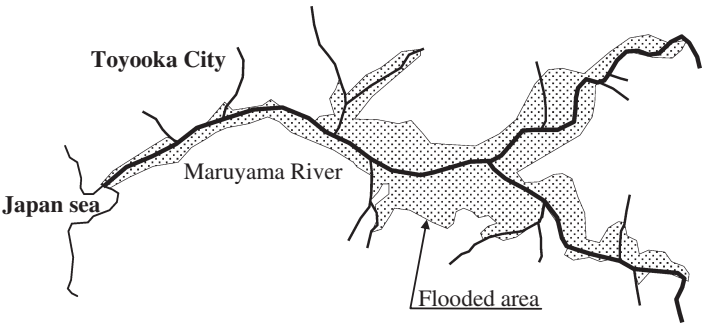

Figure 4.32: Outline of Maruyama River.

Figure 4.33: Flood of the Maruyama River.

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Figure 4.34: A part of levee collapse.

Figure 4.35: Restoration of wetland.

Figure 4.36: Restoration of continuous channel.

The rehabilitation of the Maruyama River was planned by the Ministry of Land, Infrastructure and Transportation in Japan as follows:

1. *From 2004 to 2005*. Structural measures were rehabilitation of broken point of the embankment, levee heightening in a part of river, and levee heightening to high water level +0.5 m in embankment section. Non-structural measures were publication of inundations map by typhoon, assistance to prepare flood hazard map, provision of river image, announcement of alert through cellular telephone, establishment of Disaster Information Committee in Maruyama River, and functional enhancement of disaster prevention facilities.
2. *By 2009*. Implementation of emergency project for serious damage, excavation of river channel, banking, measures for landslide water, bank strengthening, reconstruction of bridge, reconstruction of weirs, and building a coalition in area.
3. *By 2014*. Flood control basin project. Hyogo Prefecture in Japan adapted the construction methods in consideration of ecology of stork and Japanese giant salamander as special protected animal.

The hazard map of Toyooka City in Hyogo Prefecture is designed to prepare evacuation map by each household and 'Let's prepare evacuation map of my home!' is included in it. Four steps to prepare map are described as follows: step 1, assumed maximum flood water depths in case of dike break are separated by color on the reverse of map. Firstly, you need to find your house and confirm assumed flood water depth. Step 2, secondary, you need to confirm your shelter and route to it. You need to avoid using route near river. Step 3, let us walk to shelter with your family. On the way to shelter, you need to check hazardous places with disaster map so that you can confirm the route which is safe and easy to evacuate. Step 4, let us prepare evacuation map of my home to reach shelter safely. You need to mark the hazardous points, landmark, and other and confirm the most safe evacuation route.

Two types of signboard, 'Flood Water Depth' and 'Flood Evacuation shelter', among 'Ubiquitous Hazard Mapping Project' were installed in Toyooka City.

Ministry of Land, Infrastructure and Transport and Hyogo Prefecture established 'Flood Water Depth' signboards in the city. Toyooka City set 101 'Flood Evacuation Shelter' signboards at each shelter. Moreover, Ministry of Land, Infrastructure

and Transport, Hyogo Prefecture and Toyooka City continue to coordinate plan, location, etc. through coordinating committee [33].

The Kushiro River (Figs 4.1 and 4.37), which flows across the wet Kushiro Plain in Hokkaido, Japan, is slated to be returned to its original meandering form after having previously been straightened as a flood-control measure [34–37].

The Kushiro River originates from Kussharo Lake and passes down the Ramsar Convention registration damp ground and the Kushiro damp plain before flowing into the Pacific Ocean. The incidence of flooding fell once the river was straightened, but the damp plain began to dry out because earth and sand inflowing from the upper reaches of the river increased and 20% of the area of wetlands disappeared over the course of half a century. In response, the Japanese Government filled in a 1.6-km stretch of straightened river 25 years ago and brought back a 2.7-km stretch of meandering through. Flood Control Division, Kushiro Development and

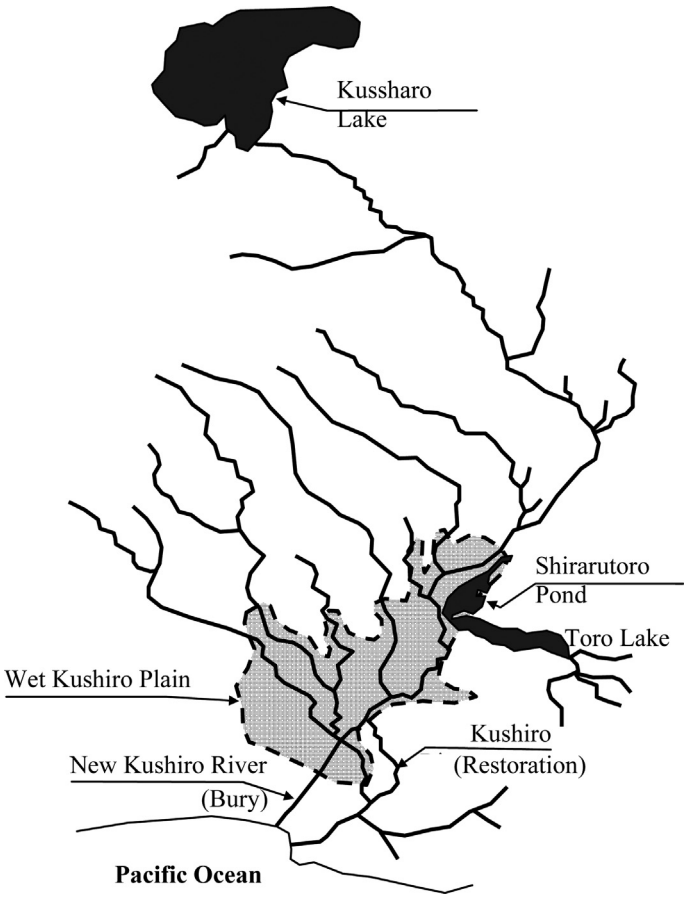

Figure 4.37: Outline of Kushiro River.

Construction Department, Hokkaido Regional Development Bureau in Japan describes about current situations and problems of the Kushiro wetland as follows: Kushiro Mire boasts one of Japan's most outstanding natural environments and serves as an important habitat for wildlife. The mire is important for human beings, too, serving as a reservoir through its water retention and purification, providing flood control as a retarding basin, and moderating the regional climate. The mire is a precious asset that should be conserved now and in the future. The recent expansion of economic activities in the catchment basin has resulted in a marked decrease in the mire area, and the mire vegetation has changed rapidly from colonies of reed and sedge to alder forest. Nature is destined to change, and the mire cannot escape its transformation to land. However, the recent changes have had a negative impact not only on wildlife but also on humans.

The Nature Restoration Project of Kushiro wetland is proposed by the Ministry of the Environment in Japan as follows: nature restoration of Kushiro wetland is treated as the model case of nature restoration. The fundamental process for restoration, starting with setting the core objective, studying the condition, planning the project, implementing the work, and monitoring the result, are named as 'Nature Restoration Kushiro Model' and will be referred for the future restoration project. The objective of restoration of Kushiro wetland is to restore the wetland condition of 1980, in which Kushiro wetland was registered under the Ramsar Convention. To achieve the core objective, following are stated as three main objectives: (1) protection and conservation of natural environment, (2) compatibility of restoration and agriculture, and (3) contribution to the local society. (1) Protection and conservation of natural environment are that prior to the restoration project, it is essential to put effort on protection and conservation of current natural environment. Nature restoration is based on the concept to not build up something new, but assist the natural auto-purification. To achieve this, the process has to be carried on not rapidly since there are so much uncertainty and complexity in natural environment, but slowly but steady. This project would go through such a long-time process to see result. (2) Compatibility of restoration and agriculture is that throughout the land reclamation for agriculture for a long time, agricultural activities have been reaches to the edge of wetland. With understanding this fact, it is essential to co-exit the restoration project on the wetland and the agricultural activities at the edge of wetland. (3) Contribution to the local society is that the restoration project is expected to be the long-time process, and be able to be considered not only to restore the natural environment, but also to contribute to the local society throughout this long-time project. For example, it can be improving the local image for sightseeing and local economy to be known as the region to deal with natural restoration. In addition, it is planned to encourage local residents to be involved into the restoration projects, and develop the new type of public work. To fulfill these core main objectives, there are eight sub-objectives for the restoration projects in terms of procedure of project, framework of organization, and cooperation with local residents and society. Eight sub-objectives are (1) setting the main theme to each project, (2) scientific studying and planning, (3) monitoring and evaluation, (4) cooperation of institutions and NPO, and encouragement of

public participation, (5) open and share the information to public, (6) environmental education, (7) enhancement of lifestyle, and (8) cooperation to create reputation. Figures 4.38 and 4.39 show the difference in area of wetland between 1910s and 1980s. The area of the Kushiro wetland decreased from about 251 km^2 in

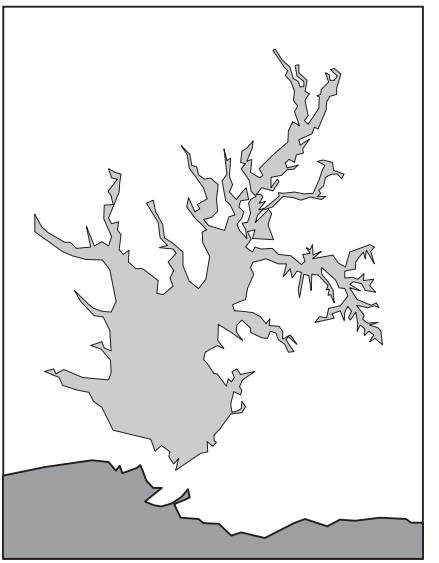

Figure 4.38: Kushiro wetland in 1910s.

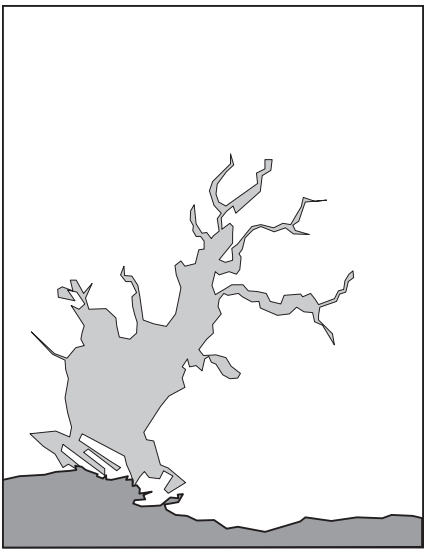

Figure 4.39: Kushiro wetland in 1980s.

1910s to about 203 km^2 in 1980s. Moreover, the area of the Kushiro wetland decreased to 195 km^2 in 1990s.

A total of 70,000 houses were flooded and 10 people died in Aichi Prefecture during flooding in September 2000 [38]. The damage amounted to 980 billion yen. This disaster represents a typical city disaster. The municipality of Nagoya City in Aichi Prefecture has developed an evacuation procedure, but during the flood event the rainfall intensity was twice the assumed rate of 50 mm/h. Accordingly, there was insufficient time to evacuate residents because of the rapid increase in water level within the river. A highway was flooded and the river overflowed into a subway station. A small river within the urban region overflowed because of the heavy rain. The Shin River (Figs 4.1 and 4.40–4.43), which collapsed during the heavy rainfall, is a small river that flows through Nagoya City. The city had been purchasing riverside land to improve the levees. A reservoir with a capacity of 100,000 m^3 is located under a road of about 100 m in width; the reservoir passes underground through the center of Nagoya City in the east and west directions. This reservoir performs the role of preventing rainwater from flowing into the river; the water is pumped into the river once the water level has subsided [39–41].

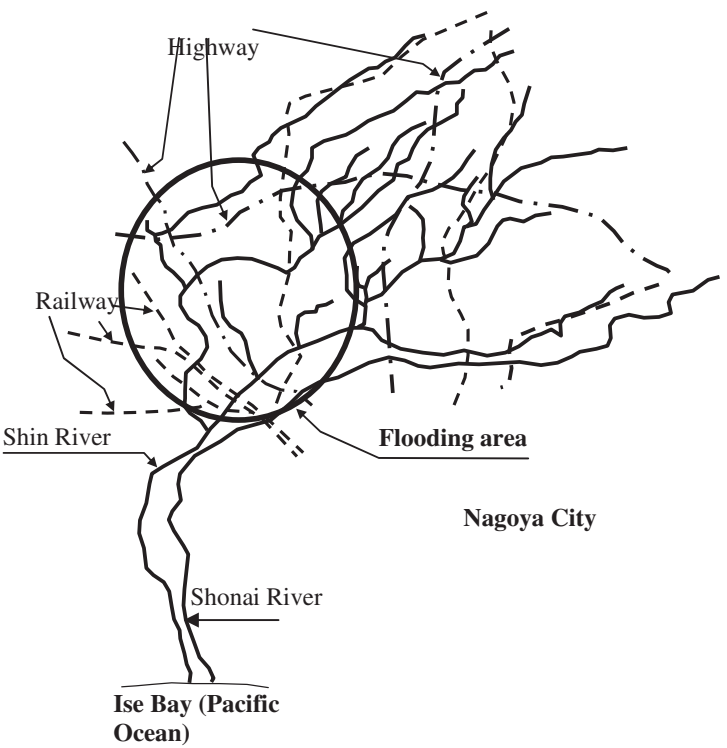

Figure 4.40: Outline of Shin River.

Figure 4.41: Aerial photograph of flooding area in Shin River.

Figure 4.42: The levee break of Shin River.

However, the reservoir was cut off at the time of this disaster and did not function. It is important to undertake measures such as the maintenance of levees, drainage works, and reservoirs; however, there is a limit to such maintenance work due to budget constraints. Therefore, it is important to evacuate residents with reference to a hazard map in case of heavy rain that exceeds assumed rainfall intensities.

After the Tokai floods in 2000, the 'Special Emergency Project as the Countermeasures against Terrible Disaster in the Shonai River and the Shin River' has been carried out by the Ministry of Land, Infrastructure and Transport in Japan. As part of the structural measures, the project includes the building of levees (raising and

Figure 4.43: The submerged area in Nagoya City.

embankment in the lower part), improvements in the bank protection, the excavation of river channels, the rebuilding and reinforcement of bridges, the raising of fixed dams, improvements in the retarding basin, and increase in drainage pumps capacity. With regard to non-structural measures, it comprises improvements related to the disaster prevention information system and to the flood-fighting bases. In Nagoya City where the Tokai heavy rain occurred, a fixed-point observation system was introduced, calling for the cooperation of residents for the provision of information on water levels and on the situation on flood levels and damages; currently there are about 700 points. Main lessons learned in the Tokai flood hazards are as follows: (1) the urban flood damage caused by the Tokai heavy rain has revealed the danger in urban areas where assets are concentrated against unexpected rainfalls. Not only in Nagoya City, but in metropolitan areas like Tokyo and Osaka in Japan, population and assets are concentrating year after year, and there is a trend in which the damage potential increases, thus making it impossible to cope with unexpected floods by means of the conventional hardware measures. Hence, comprehensive flood control measures are required that attach greater importance to software measures. (2) Regarding non-structural measures, the improvement in information networks has been incorporated into the special emergency project as the countermeasures against terrible disasters in rivers. Also, included are such activities as the review of disaster prevention plans and others, the handling of disaster prevention, the distribution of hazard maps, and others. (3) The private insurance companies should consider the enlargement of the coverage of fire insurance to also cover compensation for flood damage [42].

4.5 Concluding remarks

A disaster culture was firmly rooted in the minds of residents in previous times, but all sense of impending flood disasters has become forgotten with

the construction of levees and advances in sewage maintenance. The fluidity of inhabitants in a city is high and the disaster culture has not survived. People have changed in terms of water use with changing land use. Residential development and the construction of factories have advanced with the security provided by construction projects; however, significant damage occurs when the amount of rainfall exceeds the limit of river-improvement measures. This situation has resulted from a lack of unity in administering land use and rivers. If there is information on flood damage, it is easy to avoid such damages. The administration must hurry in reporting to inhabitants during times of heavy rain. It is difficult to pass new laws and regulations for existing cities; therefore, it is necessary at the time of rebuilding a house, for example, to construct a structure that enables rainwater to infiltrate the ground.

There are many case studies about the mitigation measures on flood hazards in USA [43–45]. The Community Rating System in USA categorizes flood hazard measures under six basic strategies such as prevention, property protection, natural resource protection, emergency services, structural projects, and public information. Preventive measures are designed to keep the problem from occurring or getting worse. They ensure that future development is protected from flooding and that it does not increase flood damage. Property protection measures are used to modify buildings subject to flood damage rather than to keep floodwater away. Natural resource protection measures are that water quality and natural habits may be improved, and flood losses reduced, by preserving or restoring natural areas or the natural functions of floodplain and watershed areas. Emergency services measures protect people during and after a flood. Structural projects measures are used to lower flood elevation profiles and to prevent floodwater from reaching flood-prone areas. Public information measures advice property owners, potential property owners, and visitors about the hazards, ways to protect people and property from the hazards, and the natural and beneficial function of floodplains [46].

The continuation of a Basin Committee established at the district maintenance station of the Ministry of Land, Infrastructure and Transport, Japan, has been placed in danger [47]. The River Law of Japan was revised in 1997 to ensure that river plans reflect the opinion of local inhabitants. This is the first step of a Basin Committee method that includes local inhabitants in deliberations concerned with river planning. The Basin Committee gave a commitment in 2003 not to build new dams. In contrast, the Bureau of Rivers within the Ministry of Land, Infrastructure and Transport, Japan, blocked the construction of just two of five dams proposed in 2005. It is now common for local residents to oppose the construction of new dams. As the true intention of the Ministry of Land, Infrastructure and Transport, Japan, is to suppress the voice of local residents, the Basin Committee is necessary because there is opposition to new dams. As residents participate in meetings of the Basin Committee the interest taken in a river increases among residents and they try to maintain a river according to the revised River Laws; consequently, residents are aware of the dangers during floods and are involved in improving local disaster prevention measures.

The democratization of river administration in Japan is going to start under the resident participation [48]. We must select in a public enterprise whether the best is the development or the environmental protection.

A disaster has a proverb to come over when we forget it. How can we protect ourselves from a flood? It is important to know what is to do before, during, and after a flood.

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