14 Nature-Based Solutions for the Restoration of the Abukuma River Basin (Japan) After Typhoon Hagibis

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Abstract

In October 2019, Typhoon Hagibis hit many areas of Japan, including the Abukuma River Basin. It brought enormous precipitation and caused many river banks to break, resulting in serious flood disasters. In the Abukuma River Basin, there is a structure called the Hamao flood retention reservoir, which was constructed in 2004 as an environmentally friendly means of flood control. However, its sluice gate was broken by the river's increased flow of water causing a serious flood in the neighboring area. Having previously experienced such floods, such as those which followed heavy storms in July 2020, national and local authorities changed the direction of flood management policy to a basin-wide approach (*ryuiki-chisui* in Japanese). With this policy change, the reconstruction of the river banks has been conducted. The concept for reconstruction employs modern engineering flood control techniques as well as traditional ones, effectively depending on the characteristics of given sites. This chapter clarifies how officials are integrating nature-based solutions or ecosystem-based disaster risk reduction. Also, it discusses the future tasks in the implementation of basin-wide approach flood management integrating NbS.

Keywords

Nature-based solutions · Flood management · Typhoon Hagibis · Disaster risk reduction · Japan

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14.1 Nature-Based Solutions in Flood Management in Japan

The issues of disaster prevention with hard infrastructure have had to be reconsidered regarding the increasingly extreme climate and meteorological events that have become unprecedented in frequency and extreme level. A report by leading scientists calls this weather extreme “a new normal” (Pihl et al. 2019, p. 17). Floods have increased and measures have been called for, introducing a concept of “nature-based solutions (NbS)” in a broader sense, which is different from the protection of specific species and communities in the narrow sense and the ecosystem conservation approach (IUCN 2020). Since around 2008, the definition of a new nature conservation gear has been studied, in which clear discussions and brute force processes are not always sufficient in Japan. Estrella and Saalismaa (2013) define “ecosystem disaster mitigation” as “the sustainable management, conservation and restoration of ecosystems to reduce disaster risk, to achieve sustainable and resilient development (p. 30)” citing Sudmeier-Rieux and Ash (2009), “sustainable management, protection and restoration.” With this definition, it can be understood that ecosystem disaster mitigation envisions two possible practices: conservation and protection of existing natural ecosystems and a new restoration of lost natural ecosystems. Meanwhile, the International Union for Conservation of Nature (IUCN) has addressed NbS as societal issues and tasks such as climate change, food security, water security, human health, natural disasters, and social and economic development in a highly adaptable and effective manner. It is defined as “actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” (Cohen-Shacham et al. 2016).

Floods larger than the planned scale are called “excess floods” but as long as it is premised on intensified rainfall due to climate change. If the location of the collapse is in a densely populated residential area, the damage is only for continuous embankments where the precise location of the collapse is unknown. The damage will be enormous. Even if equal safety is ensured up to the planned scale, it is necessary to determine in advance areas which can be flooded intentionally to prevent excessive flooding and damage can be minimized. This is a rebellion-tolerant hydraulic control measure, and we can learn the basics of this feeling from the traditional NbS technologies such as *Kasumi-tei* (open levees), *etsuryu-tei* (overflow levees), flood-protecting forests, etc.

Kasumi-tei (open levees), *etsuryu-tei* (overflow levees), and flood protection forests, which are traditional hydraulic control methods for rivers, are traditional green infrastructures that first appeared in the sixteenth century and remain today. Unfortunately, since the enactment of the River Act in 1896, the need for high-water construction has been called for, and the idea of Western European technology to flush floods with embankments has been adopted, resulting in that the traditional hydraulic technology has gradually become less recognized. However, in the time of “a new normal” as mentioned above, more attention has been paid to such traditional flood control techniques as an approach of NbS. The following sections introduce a few representations of traditional flood control methods used from early times in Japan.

14.1.1 Traditional Nature-Based Solutions in Japan

In late nineteenth-century Japan, the flood control experts of the time, Odaka Junchu and Nishi Moromoto, said "river banks are like as armor" in their books (Takahashi 1971). It means that the damage may be more severe when one wearing armor is hit by bullets. Thus, they warned people about placing too much emphasis on building strong banks, as we build much stronger and higher banks expecting more security once we build it. Also, they pointed out that stormwater level gets higher by building riverbanks or dikes. This precisely tells us about the vulnerability of modern society that has depended much on "gray" infrastructures, such as dams, paved embankments, and roads.

14.1.1.1 Kasumi-Tei

Kasumi-tei is a type of discontinuous levee system that was used from the seventeenth to mid-nineteenth centuries in Japan to mitigate the impact of river flooding (Sendo and Ishikawa 2018). The Kasumi-tei levees are funnel-shaped, and the openings allow stormwater exceeding the river channel capacity to spread backwards, reducing the river discharge, and return to the channel when the floods withdrew (Fig. 14.1). Sendo and Ishikawa (2018) elucidated that the funnel-shaped levee openings effectively help a portion of stormwater exceeding the river capacity

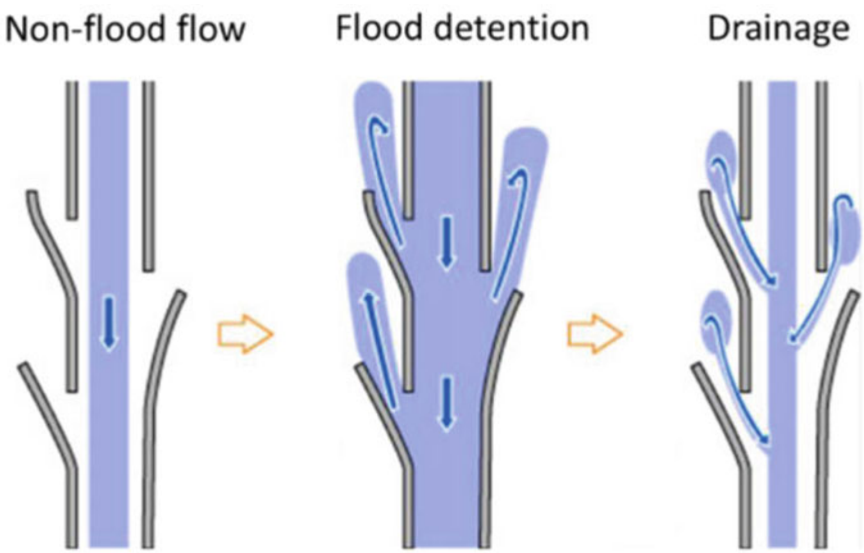


Fig. 14.1 Typical Kasumi-tei levee arrangement (source: Sendo and Ishikawa, 2018)

to spread when flooding and return to the main river through computational simulation.

According to Okuma (1987), who has been studying the arrangement and function of Kasumi-tei levees for many years, it is carried out in steep alluvial fan-shaped gravel rivers of 1/500 or more, and in gentle low-flat sandy rivers of 1/1000 or less. It has been pointed out that the purpose is different upon implementation. The former is designed to return floods that have overflowed and flooded to river channels and to eliminate inland waters. It is thought that the flood control function is dependent on backflow, which is often said to be limited by steep terrain and therefore slight. In the Tedori River, in southern Ishikawa Prefecture and other areas, some Kasumi-tei levees overlap over 1 to 2 km and even above the water levels that rise during floods. First of all, the embankment facing the river prevents flooding, and if the embankment alone fails and collapses, the idea of defense in detail is to minimize flooding with the overlapping rear embankment.

14.1.1.2 Nokoshi (Overflow Levee)

Nokoshi is another example of flood damage mitigation used from early times in Japan (Fig. 14.2). In the Jobaru River in Saga Prefecture, many overflow levees called "Nokoshi" remain to this day, which provides valuable knowledge for understanding the effects of overflow levees. A pair of "Nokoshi" levees was set up along the river, protecting nearby villages from flooding, which played an important role in reducing damage to the inland area of the embankment. Unfortunately, the importance of the embankment's function has not been well understood, and like the Kasumi-tei levee, many levees have been removed for field maintenance and road construction (Tanabe and Okuma 2001). Residential land development is progressing around the Jobaru River Basin and retarding basins, and the risk of exposure to disasters is increasing during overflows. Currently, hydraulic control by the Jobaru River Dam is being considered, and a plan to eliminate Nokoshi has emerged, but it is clear that the dam has its limits in preventing excessive floods. Inundation-tolerant basin hydraulic control should be considered by utilizing Nokoshi and Kasumi-tei levees. Some flood inundation simulations have been

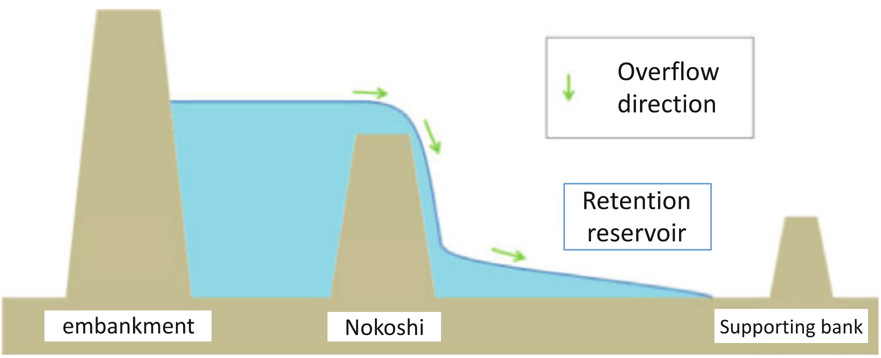


Fig. 14.2 A cross section of "Nokoshi" (modified Nakajima and Ogushi, 2012)

conducted to verify the effects of Nokoshi and Kasumi-tei levees on the Jobaru River, if the flow rate of the main river increases, causing overflow from Nokoshi and Kasumi-tei levees (e.g., Nakajima and Ogushi 2012; Teramura and Shimatani 2021). If there ever were such a case, the water level of the main river would hardly rise at all.

14.1.1.3 Etsuryu-Tei (Overflow Levee)

Due to flood control, the structure is such that floods flow over the embankment. When a part of the embankment is lowered and the flood exceeds the height of the overflow embankment, a part of the flood flows over the overflow embankment into a retention reservoir or a regulating pond. The surface of the overflow dike must be covered with concrete or asphalt so that it will not be damaged by the flow of the water, and it must have a strong structure (MLIT 2012). The zone between the levees can be a floodwater retention reservoir, hence a green infrastructure.

14.1.1.4 Bobirin (Protecting Forests)

Bobirin is an artificial forest created to prevent and mitigate damage to residential land, roads, agricultural land, etc. from disasters caused by natural phenomena or human causes. Although these forests may be built by the private sector or individuals, they are often designated as "protection forests," based on the public interest functions stipulated in the Forest Law. Of the various protection forests, the following 11 types correspond to disaster prevention forests established to prevent disasters: (1) sediment runoff protection forests (for preventing sediment runoff and erosion by roots and fallen leaves), (2) sediment collapse defense protection forests (for the prevention of unstable ground collapse), (3) flying sand protection forests (for preventing flying sand), (4) windbreak protection forests (for prevention of damage caused by strong winds), (5) flood protection forests (prevention of flooding of rivers and mitigation of water force), (6) tidal damage protection forests (to prevent damage caused by tsunami and storm surge), (7) snow protection forests (protecting roads and railroads from snowstorms), (8) fog-proof protection forests (protecting cultivated land from sea fog), (9) avalanche protection forests (to prevent avalanches and to act as a buffer zone when they occur), (10) rockfall prevention protection forests (to control the danger of rockfall), and (11) fire protection forests (to prevent the spread of fire with fire-resistant tree species) (Watanabe 1998). In the Japanese context, *satoyama* forests prevent and mitigate sediment disasters from hitting nearby villages and help in mitigating crop damage by wild animals (MoE 2016).

14.2 Abukuma River Basin Restoration

The Abukuma River is 239 km long, and its basin area is 5400 km^2, located in the southern part of the Tohoku Region (the northeastern area) in Japan (Fig. 14.3). Its headwater is located at Mt. Asahi (1835 m above sea level) in Tochigi Prefecture and runs through Fukushima Prefecture and Miyagi Prefecture, from south to north,

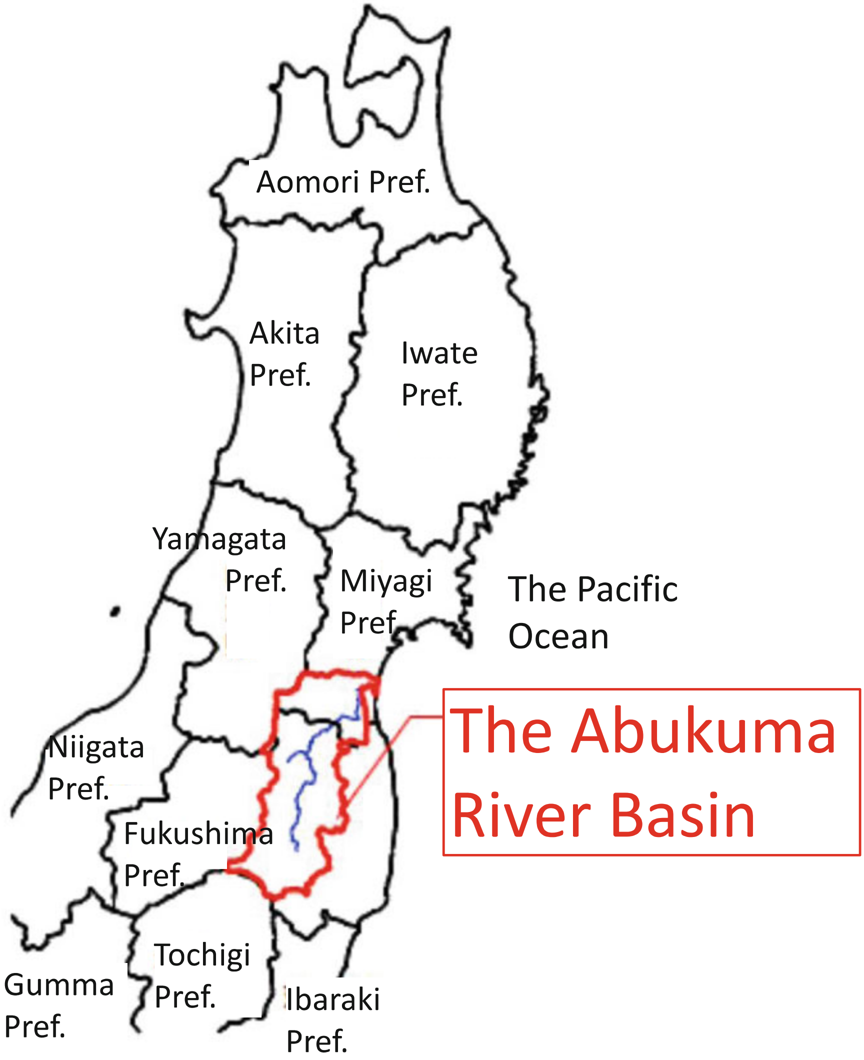


Fig. 14.3 Location of the Abukuma River Basin (modified from MLIT 2012)

emptying into the Pacific Ocean. The basin has a population of 1.3 million. The average annual precipitation is 1100 mm in the plains and 1200–1500 mm in the mountain areas. The river improvement project using modern techniques started in 1919 (MLIT 2021).

14.2.1 Hamao Retention Reservoir

Construction of the Hamao Retention Reservoir began in 2004 as an environmentally friendly method of flood control, and the retention reservoir was completed in 2012 (MLIT Tohoku Region Development Bureau 2012). In addition, to formulate a utilization plan for the retention reservoir, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) held workshops in which residents also participated and carried out in collaboration with the local community.

The Abukuma River system was severely damaged by a flood in August 1998. For this reason, various studies have been conducted so that even if a similar flood occurs in the future, the flood can be safely mitigated. The Hamao Retention Reservoir temporarily stores part of the water that flows through the river during floods, reducing the amount of water that flows downstream. The traditional technique of etsuryu-tei (overflow levee) has been employed at the Hamao Retention Reservoir. In addition, the improvement of the embankment and the excavation of the river channel and the Hamao Retention Reservoir, which is to be carried out in the "Great Heisei Renovation," will aim to reduce the flood damage downstream. Thus, urgent maintenance was carried out to reduce flood damage caused by floods on the same scale as the August 1998 flood. The area size of the Hamao Retention Reservoir is 75 hectares. The retention capacity was improved from 1.8 million square meters up to 2.3 million square meters by excavation work (MLIT Tohoku Region Development Bureau 2012). Figures 14.4 and 14.5 show the overview of the Hamao Retention Reservoir and the Abukuma River.

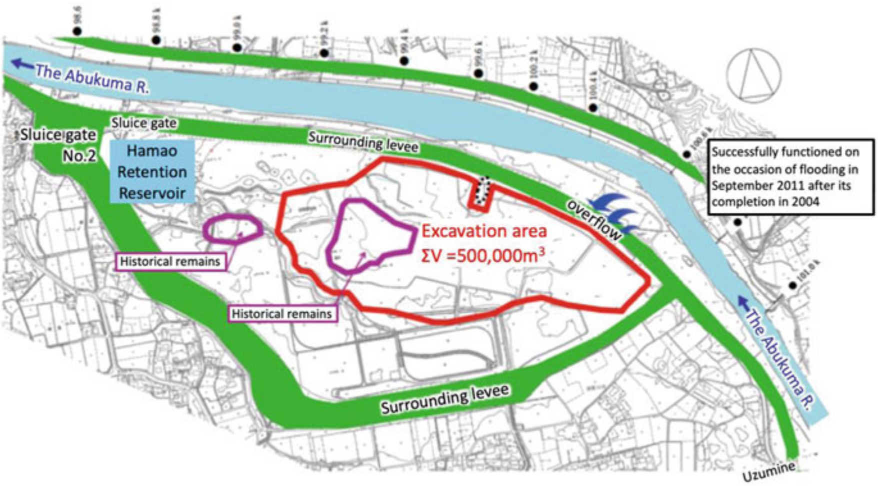


Fig. 14.4 Overview of Hamao Retention Reservoir (modified from MLIT 2012)

Fig. 14.5 Pooling the flood water successfully (2.6 million square meters) at Hamao Retention Reservoir (modified from MLIT 2012)

14.2.2 Typhoon Hagibis Hits Japan

Typhoon Hagibis called "Typhoon No.19" or "2019 East Japan Typhoon" in Japan formed in the central Pacific Ocean on 5 October 2019 and made landfall on mainland Japan on October 12 with a central atmospheric pressure of 955 hPa (at 18:00 on 12 October). The typhoon moved from south to north, across the Kanto and Tohoku Regions until heading out into the Pacific Ocean (Japan Meteorological Agency 2019).

Typhoon Hagibis caused record precipitation and floods in widespread areas of eastern Japan including the Abukuma River Basin in Fukushima Prefecture. As the Abukuma River flows from south to north, the Typhoon Hagibis took its route along the Abukuma River with enormous rainfall from the upper river basin to the downstream basin, bringing such enormous amount of rainfall that exceeded the

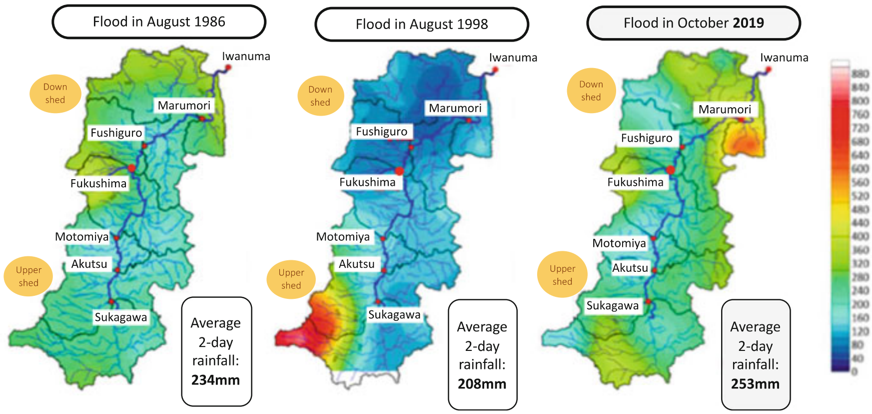


Fig. 14.6 Average 2-day rainfall at Fukushima Observation on the occasions of historical floods in 1986, 1998, and 2019 (modified from MLIT 2020b)

designed discharge of the bank (Kitamoto 2019; The Sankei 2019). Throughout the basin, more than 200 mm rainfall, which is more than double the monthly average in the area, was observed in only 48 h. The characteristics of the rainfall were temporal concentration and spatial distribution. This brought record discharge. At Fukushima Observatory, an estimated actual discharge was 6020 m^3/s, which exceeded both the record of 4310 m^3/s in 1941 and even the interim river improvement goal of 4600 m^3/s (MLIT 2020b). It resulted in a 2-day average rainfall of 253 mm, which exceeded historical record floods in 1986 with 234 mm/2 days or in 1998 with 208 mm/2 days (MLIT 2020b) (Fig. 14.6).

14.2.3 Damages at the Hamao Retention Reservoir

When typhoon Hagibis struck the Abukuma River, various types of infrastructures were damaged, limiting waterway capacity and causing a severe flood disaster throughout the entire basin. The damage of Hagibis in Fukushima Prefecture resulted in 38 deaths (direct, 32; indirect, 6) and left 59 people seriously injured. Damage to houses and other properties resulted in 1434 total collapses, 12,010 semi-collapses, and partial damage to 2005 houses. 1022 houses were inundated higher than the floor, and 432 houses inundated below the floor as of 13:00, 13 July 2021 (Fukushima Prefectural Government 2021).

On 13 October 2019, when the typhoon struck the Abukuma River Basin, the embankment in the Hamao district of Sukagawa City, Fukushima Prefecture, broke for an extension of about 50 m. The surrounding area was flooded. Tohoku Jisei, which manages rivers, established a Committee of Experts on October 14, the following day. After that, the cause of the levee breach and the restoration method were examined three times until December 2 (Nikkei Tech 2020). The Expert Committee investigated the damage situation at the location of the collapse

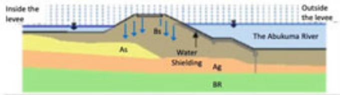
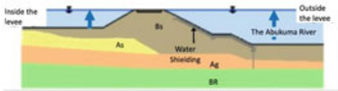
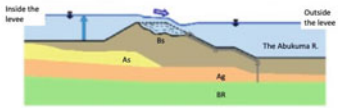
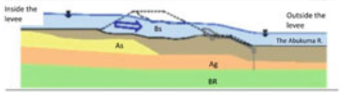
Levels	Process	Cross-section
1 Strom rain Water level rises	- Torrential rain exceeds the designed water level	
2 The water level inside the levee rises and overflows at the upper side of the levee.	- Water levels rise further and the water level inside the levee also rises with overflowing water.	
3 Overflow from inside the levee and corrosion at the top of the levee.	- Water in the reservoir and overflowing water concentrated at the breaking point (sluice gate No.2) which brings the water level inside the reservoir higher than the river water level. - Erosion on the levee surface occurs.	
4 Levee failure (the levee breaks)	- Erosion expands quickly. → The levee breaks.	

Fig. 14.7 Embankment collapse mechanism concluded by the Committee of Experts (source: MLIT Tohoku Regional Development Bureau)

immediately after the typhoon. Upon first inspection, it was thought that there was a possibility that water had overflowed from the embankment side where residential areas and paddy fields are located.

The damage caused by the heavy rainfall above was the inland flood. An additional cause of flooding was due to a large volume of runoff water being stored inside of the levee of the Abukuma River (Kawagoe 2019), and the Hamao Retention Reservoir was not an exception. The embankment in the Hamao district of Sukagawa City, Fukushima Prefecture, was broken for an extension of about 50 m, and the surrounding area was subsequently flooded as mentioned earlier. Due to the record heavy rainfall of the typhoon, the water level of the Abukuma River rose and remained above the designed high-water level for a long period of time. In the Hamao area, the water level on the embankment side rises due to flooding and inland water from upstream. This flood caused overflow to the river to reach beyond the height of the embankment. The top of the flooded area was paved with asphalt. However, when overflowing, a water level difference occurs between the river surface (river) side and the levee inside, and a lifting pressure exceeding its weight acts on the asphalt at the top. In this case, the asphalt was peeled off and washed away, and the embankment near the top was washed away as well. Figure 14.7 shows the mechanism of the main collapse of the levee at the Hamao Retention Reservoir, as reported by the Committee of Experts.

14.3 Basin-Wide Flood Management Approach

High-water construction is planned to suppress the flooding of rivers when the water level of a river is high, that is, in the event of a flood, to temporarily store river water in a dam or to drain it to the sea earlier by the drainage channel construction. It is the basic concept of current river construction. However, in the 2019 Typhoon Hagibis disaster, floods exceeding the planned scale occurred in various parts of the country such as Chubu, Kanto, and Tohoku, the embankments broke at 140 places, and many houses were swallowed by muddy water. While being asked how to adapt to climate change, disaster prevention technologies that keep flood currents in river channels by conventional embankments have exposed their fragility and danger (MLIT 2020c).

14.3.1 Shifting to Basin-Wide Flood Control

The national government agreed with a consensus on the Integrated Flood Management (IFM) project of the Abukuma River on 31 January 2020 (MLIT 2020a). Also, having experienced the floods after Typhoon Hagibis and a heavy rainstorm in July 2020, the national government and several local municipal governments changed their flood control policies to a trans-sectoral, basin-wide approach as a part of IFM (MLIT 2020a). In the future, it will be necessary to systematically carry out the second stage of maintenance, taking into consideration the maintenance status of the entire Abukuma River.

Since the basin-wide approach is regarded as one whole basin including the flooded area, cooperation with all the stakeholders concerned in the entire river basin is required to reduce future flood damage. For this reason, as with the "Urgent Flood Management Project (緊急治水対策プロジェクト)" for nine water systems severely damaged by the Typhoon Hagibis and the heavy rains of July 2020, riverbank restoration was also carried out in Class-A water systems nationwide (MLIT 2020d). Furthermore, for all the Class-A water systems nationwide, MLIT formulates "the basin-wide flood management project (流域治水プロジェクト)" integrating both hardware and software in which maintenance of rivers and rainwater storage facilities, land use regulation and guidance by designating disaster risk areas, as well as preliminary discharge from water-supply dams under the management by municipality governments and private sectors, etc. are all comprehensively included (MLIT 2020d).

Based on the compilation of "full-scale disaster risk reduction (6 July 2020), the "basin-wide flood management project" has been discussed by the basin-wide flood management committee, comprised of the national government, local municipalities, private sectors, etc. "The basin-wide flood management project" in all 109 Class-A water systems nationwide was formulated and announced to the public on 30 March 2021 (MLIT 2021).

14.3.2 Integration of Traditional Flood Management Techniques in the Basin-Wide Flood Management Project

Figures 14.8 and 14.9 illustrate the whole image of the basin-wide flood management project. The basin-wide flood management project includes Kasumi-tei levees, retention reservoirs, and likely overflow levees which will be selected and installed depending on the geographical and demographical conditions in a given area. Artificial forests are also to be included in the mountainside or coastal zone.

In the case of the Hamao retention reservoir, the broken levee (the sluice gate) was restored and reinforced so that the reservoir will keep functioning to pool flood water and prevent large floods in the down shed. Taking the impact of climate change into account, construction of another retention reservoir has been planned, whose capacity will be approximately nine million m^3 in the upper shed area of the Abukuma river (MLIT Tohoku Region Development Bureau 2012). Temporal storage of floodwater in crop fields has been included in the basin-wide flood management project although it is not mentioned in Fig. 14.9. This flood control function of agricultural fields has been long recognized as one of the multifunctional

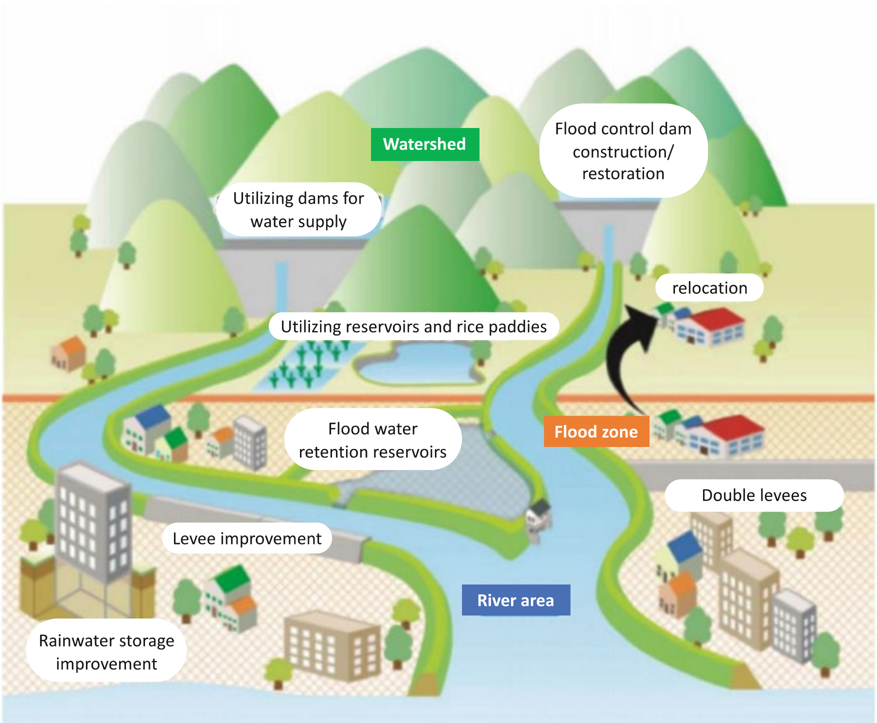


Fig. 14.8 Overall image of basin-wide flood management project (source: MLIT, 2021)

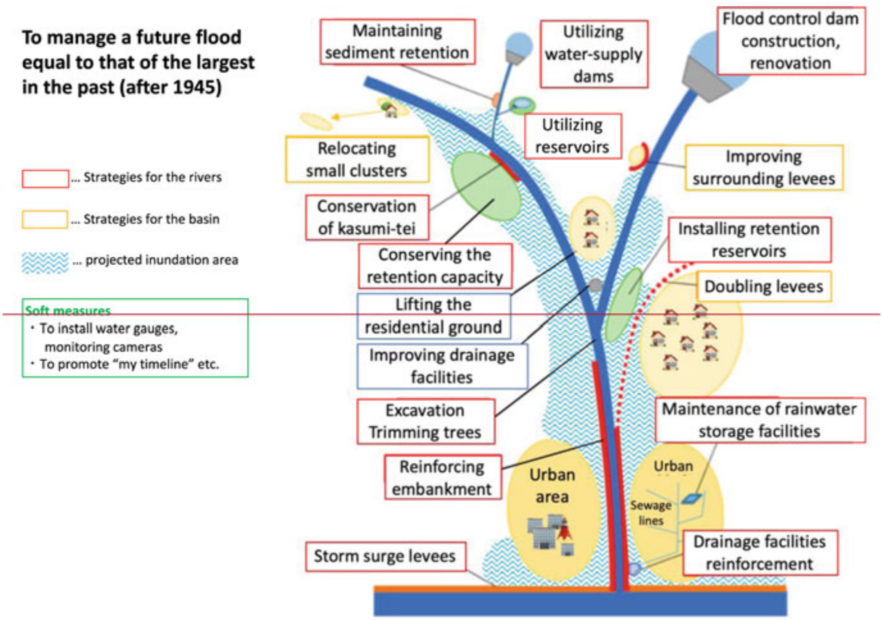


Fig. 14.9 Example measures of a river basin-wide flood management project (Modified from MLIT 2020e)

aspects of agriculture, and there is an institution called Multifunctionality Payment System (MPS) to simultaneously conserve ecosystem services, rural landscapes, etc.

14.3.3 Issues and Future Tasks

Considering climate change impacts and floods in the past, the flood management approach has been shifted to a basin-wide approach. However, the road to social implementation may still have several issues and tasks ahead. NbS for disaster risk reduction has been long discussed; however, not many cases have a proactive introduction, nor do they employ NbS in disaster risk reduction. This section offers a discussion focusing on the following three aspects: technology, economic, and coordination.

14.3.3.1 Technological Issues

The assessment methods for effects and benefits of NbS, including ecosystem-based disaster risk reduction or green infrastructure, have not been established yet (Masuda 2018). In response to these issues, the existing environmental impact assessment system can be used to promote NbS. Environmental impact assessment is the current procedure required when carrying out the development of a certain scale or larger, and businesses need to reduce the impact on the environment as much as possible.

NbS such as green infrastructure utilizes the functions of nature and can be used as an effective tool when consideration for the environment is required. In addition, the evaluation technology for environmental impact assessment and the technology for environmental conservation measures can also be applied to the evaluations and designs when introducing NbS in the future. Furthermore, the introduction of NbS through the procedure of environmental impact assessment will enable the formation of a favorable environment for those who proceed with the project (Masuda 2018).

14.3.3.2 Economic Matters

Concerning the current period of climate change, a hybrid approach integrating conventional civil engineering techniques with NbS is an option for implementation considering the increase of extreme weather patterns (Furuya and Shimatani 2018). However, close attention must be paid to the cost-benefit trade-off in planning and decision-making. The higher the ratio of green infrastructure, the more expensive the cost may become. Prioritizing the cost, it might not only lessen environmental multifaceted functions but also end up a mere excessive gray infrastructure with a hint of green infrastructure as NbS (Onuma and Tsuge 2018). Isaka (2010) pointed out the risks in depending too much on modern civil engineer-based river improvement, or gray infrastructure, which increases the risk of flood and environmental damage in case a flood occurs. This corresponds to claims made by Nishi Moromoto in the nineteenth century.

The price of land and safety can be an important concern for residents as well as private sector enterprises. Results of risk assessment influence land value and may also affect the subjective safety of residents living in the area. When it comes to relocation, it takes longer and involves more steps and processes. In these cases, institution systems for subsidies for residents must be organized. To pursue such processes and avoid unwanted bottlenecks, sufficient risk communication with adequate trust between local government officials, experts, and residents is necessary (Taki 2018). Thus, solutions to economic issues lie in the hands of those who are responsible for implementing budgets, residents, and potential project beneficiaries. Without sound risk communication, the benefit of a basin-wide flood management approach cannot be achieved.

14.3.3.3 Coordination Tasks

Since basin-wide flood management projects by MLIT and NbS involve all the stakeholders in a given basin, conflicts among the stakeholders are likely to occur. Hence, coordination and cooperation are key. Disaster management requires that multilevel governance systems enhance the capacity to cope with uncertainty and surprise by mobilizing diverse sources (Neil Adger et al. 2005). Likewise, there must be cooperation among inter-stakeholder work across boundaries of knowledges, practice, priority, scale, institutional histories, and cultures (Becker 2018).

The number of stakeholders and their interests must not be underestimated when it comes to a basin-wide approach, and various aspects such as disaster risk reduction and regional revitalization are involved. With the variety of stakeholders and aspects involved, the actors who lead the coordination and consensus-making have not been clear in the past and must be clarified especially for multilevel governments, where trans-sectoral information sharing and/or communication in normal time affects emergency responses and support provision (Sakamoto and Yamori 2012).

From the case of the Abukuma River, Konami et al. (2021) assert the significance of preparedness and the role of pre-disaster discussions for consensus-making of IFM after a flood disaster as preparedness for the next occasion, in conjunction with timely, efficient response and recovery. To discuss consensus-making with response and recovery requires all parties to pay attention to local context and knowledge including emergency responses in the past disaster cases. There is no "one-size-fits-all" approach or method in strengthening collaborative mechanisms (Ishiwatari 2019). Also, the structure of flood risk is caused by the risk directly generated by the legal system, and the flood risk is caused by the indirect legal system that exerts a shadow on the rules of behavior and decision-making in political processes and governance (Isaka 2010). It requires improvement of the current systems, which takes additional time. Hence, an optional strategy for applying a basin-wide flood management approach under the current legal system must be adopted to add concepts that come out of discussions rather than denial (Kada et al. 2010). The Shiga Prefectural Government in Japan succeeded in formulating the integrated flood management ordinance in this manner, which was implemented in March 2014.

14.4 Conclusions

This chapter provided the impact of Typhoon Hagibis at the Hamao Retention Reservoir in the Abukuma River Basin as well as some Japanese traditional techniques as NbS for flood mitigation and discussed the policy of the basin-wide approach for flood management and its future tasks through literature reviews. MLIT launched the trans-sectoral-wide basin flood management project in 2020, which integrated some traditional flood mitigation techniques as NbS. The Hamao Retention Reservoir was restored by reinforcing the bank, and construction of another large flood retention reservoir has been planned. However, the tasks of technical, economic, and coordination matters are to be overcome as NbS is related to a variety of issues in many sectors. For the sound implementation of the future NbS in Japan, the following two things are crucial: (1) to make clear which actors lead the coordination and consensus-making, especially among multilevel government officials, and (2) to promote proactive interaction among all the stakeholders in the process of consensus-making.

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