A TRADITIONAL FLOOD MANAGEMENT TECHNOLOGY IN KASE RIVER BASIN, JAPAN

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ABSTRACT

Watercourses of some rivers in Saga Plain have been rerouted in the Warring States period or early Edo period and they have unique shapes. As there have been many lowland areas in this plain, problems of water shortage and inundation occurred frequently. Therefore, sophisticated irrigation and drainage systems exist in this area and the rerouting of the watercourses may be considered inevitable. There are many flood damage prevention facilities in the river or near the river of the Saga Plain. It is significantly useful to find out and restore these remains and clarify their functions to consider a future flood control, including catchments basin operations. In this study, a traditional flood management technology in Kase River basin, Japan, is discussed, and its usefulness for the future is explained.

Keywords: Kase River, overflow embankment, auxiliary levees in the residential area, retarding basin, Saga Plain

1. INTRODUCTION

Saga Plain, Kyushu island, Japan almost consists of lowland and many inundations occurred inside levee during heavy rainfall in the residential area. In this area, especially in the deltaic area, water levels of the rivers are usually affected by tides of the Ariake Sea, whose tidal range is largest in the nation. On the other hand, in the higher area, natural levee zone and alluvial fan are seen, and river flood damages often occurred. Full-scale countermeasures against these flood disasters were done mainly from the early Edo period in Japan. Many flood damage prevention-mitigation facilities were made inside and outside of the river in Saga Plain. For examples, there were many retarding basins, overflow embankments (Nokoshi), flood restraining forest belt, and auxiliary levees in the residential area, which control a direction and magnitude of flood flow. At present, several of these facilities for flood control are left and can be seen as historical remains. Moreover, some flood damage prevention facilities are still active. It is significantly useful to find out and restore these remains and clarify their functions to consider future flood management, including catchments basin operations.

In the year of 2000, the River Council in Japan intermediately reported "Ideal methods of effective flood control including catchments basin operations" as found in the MLIT report (2000). In the report, they discuss not only the flood control measures by ordinary riparian works but also the disaster reduction for the flood exceeding design levels. In Saga Plain, these countermeasures against flood by using catchment basin operation had been used about 400 years ago. In this study, a traditional flood control technology in the Kase River basin is discussed, and its usefulness is clarified by focusing on the historical remains for flood management in this area.

Figure 1 Saga Plain and watercourses of the rivers and irrigation ditches. Some watercourses are rerouted.

2. INTRODUCTION OF TRADITIONAL FLOOD MANAGEMENT TECHNOLOGY IN SAGA

Figure 1 shows a map of the rivers in the Saga Plain. Watercourses of some rivers were rerouted more than 400 years ago, and they have unique shapes. Due to lowland in this area, water shortage or inundation occurred frequently. Therefore, sophisticated irrigation and drainage systems exist in this area, and the rerouting of the watercourses may be considered inevitable. A full-scale flood control system with water-utilization in Saga

Plain was formed in the early Edo era, i.e., about 400 years ago, as found in Ohgushi and Kuroiwa (2008). As examples of flood control systems, flood damage prevention facilities are widely distributed in the Saga Plain. Overflow embankment (Nokoshi) is a typical facility. Not only the overflow embankment but also retarding basin, flood restraining forest belt, and auxiliary levees in the residential area (Mizuuke-tei) are found to be used systematically and effectively for the flood control.

2.1 Overflow embankments (Nokoshi)

There were overflow embankments (Nokoshi) along the main river levee of the rivers in Saga Plain. The first overflow embankment in Japan was that of the Kikuchi River, which was made by Kiyomasa Kato, Feudal Load of Higo Clan in Kumamoto. In Saga Plain, Hyogo Naritomi, Chief Retainer and river engineer of Hizen Clan in Saga, made many flood control facilities like overflow embankments along the main river levee. Nowadays, we cannot see such overflow embankments so much along the Kase River, but some still exist along the Jobaru River in Saga Plain. Roles of the overflow embankment are to decrease flood discharge, defense of the downstream river levee, and river structures. When the water level exceeded the level of the overflow embankment, excess water once flowed into the retarding basin. However, with the development of the catchment basin and raising of the river levee elevation, nowadays, a use of the overflow embankment itself becomes difficult.

2.2 Flood restraining forest belt

In the middle interval of Kase River, bamboo groves are luxuriating along the low water channel as the flood restraining forest belt. Its role has been understood as sifting of sediment and fixing of the low water channel. Another function is turning away of flood direction from the river bank by storing the water in the high water channel by surrounding this high water channel by the dike. This makes the stagnant volume of water to protect the river bank from collapse.

2.3 Auxiliary levees in a residential area (Mizuuke-tei)

There were many auxiliary levees in the residential area (Mizuuke-tei) in Saga Plain. They could decrease the flood damage against the residential area. In the 1940s, severe flood disasters occurred in this area, but this Mizuuke-tei protected the villages from direct attack of the flood flows. However, nowadays, the flood control facilities in the residential area also disappeared because of the redeployment of arable land. At present, several facilities of the flood control are left and can be seen as historical remains. It is significantly useful to find out and restore these remains and clarify their functions to consider future flood control, including catchments basin operations. Figure 2 shows one of the overflow embankments (Nokoshi) and the auxiliary levees in a residential area (Mizuuke-tei) of Kase River at Saho district. This aerial photograph was taken in 1948 by the US military, and the present situation of this area is a little bit different because the overflow embankment is raised to normal levee height. Flood flow reduced by both side's retarding basin in the river and crossing levee (Yokotei) goes adversely into the retarding basin outside of the river through the overflow embankment (Nokoshi). However, by the riparian forest, it slowly flows into the retarding basin outside the river. Moreover, auxiliary levees (Mizuuke-tei) protect the villages from the water flow's attack.

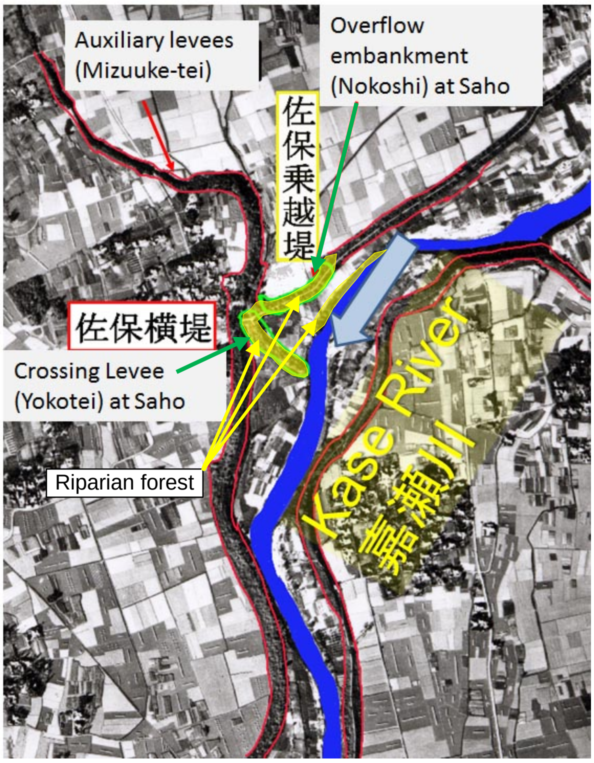


Figure 2 Overflow embankment and auxiliary levee at Saho district of Kase River basin

3. CATCHMENT BASIN OPERATION BY THE TRADITIONAL FLOOD MANAGEMENT

3.1 Retarding basin against overflow from the main river levee

Figure 3 shows sediment deposition map when the Kase River's right levee collapse in 1949 due to Typhoon Judis. The collapse occurred near the Hirata overflow embankment. Many sediments flowed and deposited. The

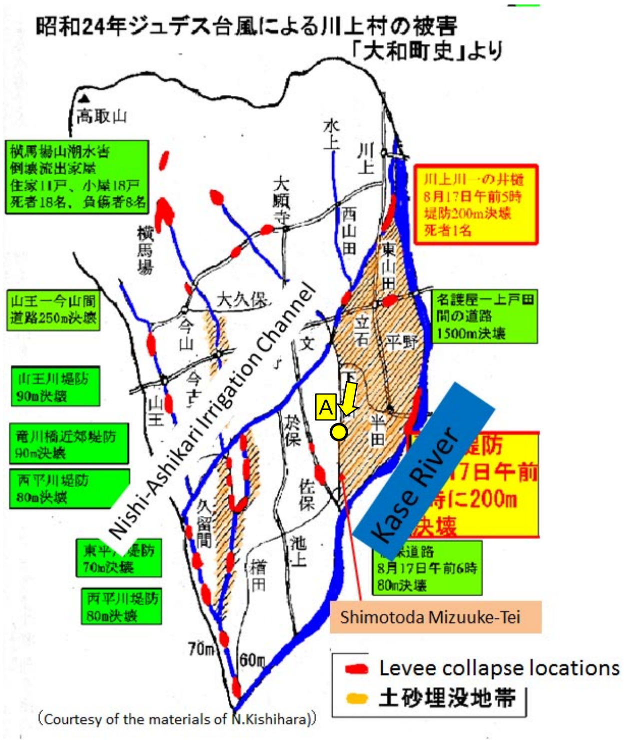


Figure 3 Function of Mizuuke-tei in Kase River basin when the levee collapse due to typhoon

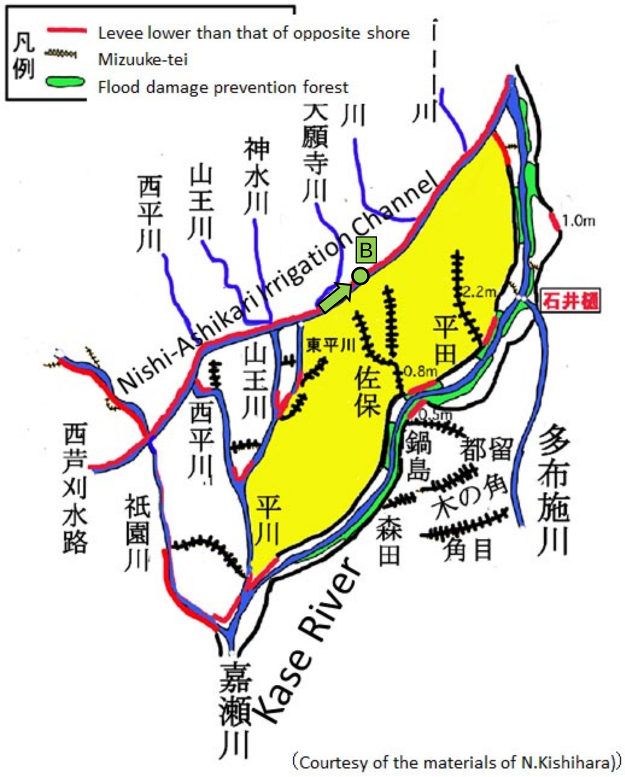


Figure 5 Retarding basin against overflow from the main river levee (Yellow areas are retarding basins)

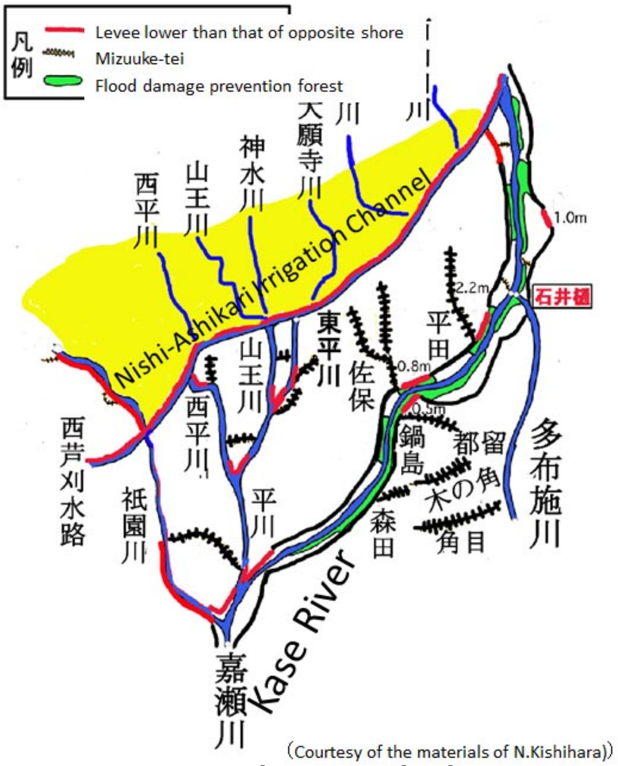
Figure 4 Shimotoda Mizuuke-tei in Kase River basin (Location and viewing direction are shown at "A" in Figure 3)

Figure 6 Nishi-Ashikari Irrigation Channel (Location and viewing direction are shown at "B" in Figure 5)

boundary of sediment deposition is corresponding to the Mizuuke-tei of Shimotoda, north to south line. Moreover, there is no sediment deposition more north of the Nishi-Ashikari irrigation channel. Figure 4 shows a photograph of Shimotoda Mizuuke-tei. Against flooding flow from the overflow embankment, there is a substantial effect of flood control by the Mizuuke-tei with riparian forest. Figure 5 shows a retarding basin against overflow from the main river levee on the right hand side of the Kase River. A yellow area is a retarding basin in which the mainstream water is overflowed from the Kase River.

3.2 On-the-spot retarding basin

Figure 6 shows a photograph of the Nishi-Ashikari Irrigation Channel in which the irrigation water flows to the south-west area. A typical feature of this irrigation channel is that the left levee only exists. Both sides' levee height difference is about 1.3m. Figure 7 shows an on-the-spot retarding basin. The water of six rivers from the north are going into the Nishi-Ashikari Irrigation Channel. When inundation occurs, the water of the north of the Nishi-Ashikari Irrigation Channel starts to be stored. For example, Higashi-Hira River starts to flow to the south from the Nishi-Ashikari through overflow embankment during the flood, as shown in Figure 8. Gates of Todate Bridge are usually closed. Higashi-Hira River is a floodway and usually dry. Once the water level of the



(Courtesy of the materials of N.Kishihara))

Figure 7 On-the-spot retarding basin

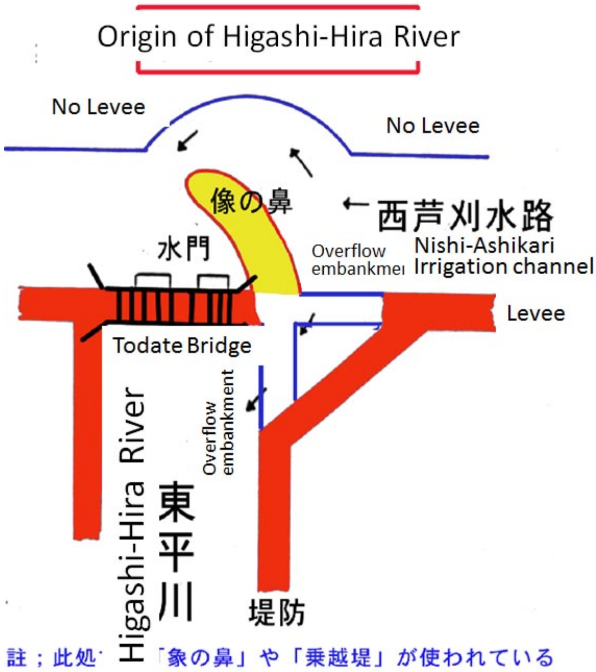


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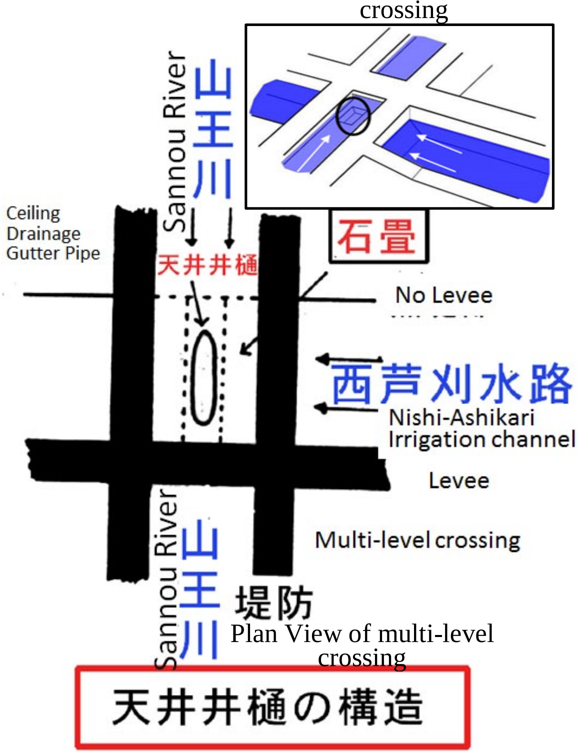
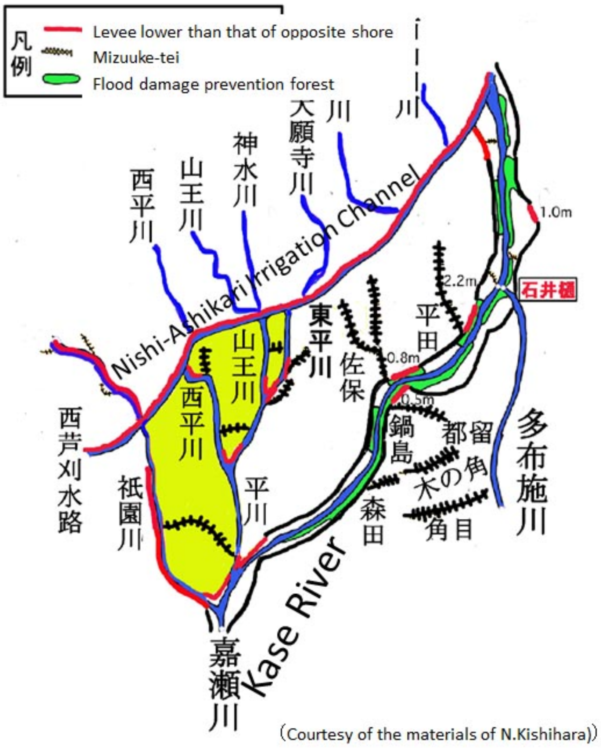
Figure 8 Higashi-Hira River and overflow embankment

3D View of multi-level crossing



註）通常は山王川の流水は天井井樋により西芦刈水路に落下し、下流には流下しない (Courtesy of the materials of N.Kishihara))

Figure 9 Sannou River and Ceiling drainage gutter pipe



(Courtesy of the materials of N.Kishihara))

Figure 10 Retarding basin considering the water surface level of the tidal river

Nishi-Ashikari Irrigation Channel increases up to the designated level, overflow starts through the overflow embankment. Another example is the Sannou River, which is another river flowing into the Nishi-Ashikari Irrigation Channel. Figure 9 shows the case of Sannou River that is multi-level crossing with the Nishi-Ashikari Irrigation Channel. There is a hole on the stone pavement at the bottom of the Sannou River, and usually the water falls into the Nishi-Ashikari Irrigation Channel. However, once the water level of Nishi-Ashikari

Figure 11 Levee height differences and retarding basins in Wannai district between Kase River and Gion River (The green color levees are higher than the opposite side levees, whereas the red color ones are vice versa)

Figure 12 A confluent point of Higashi-Hira River and Sannou River, corresponding to the retarding basin ⑥ in Figure 11

Irrigation Channel increases up to the designated level, the water plugs by itself and flood water go downstream of the Sannou River. When more torrential rain continues and the situation becomes dangerous to the villages, the water of Higashi-Hira River, etc. start to flow to the south.

3.3 Retarding basin considering the water surface level of the tidal river

Nishi-Hira River, Sannou River and Higashi-Hira River merge to Hira River. Hira River, Gion River and Kase River merge. This point is a run-up limit of seawater. When the flood and high tide occur at the same time, the flood water goes to the north three rivers' areas through the overflow embankment at the confluent point. This system is functioning as another type retarding basin, as shown in Figure 10. Dr.Kishihara surveyed the levee height differences and retarding basins of this area, as shown in Figure 11, as found in Kishihara *et al*. (2007). In this figure, Green color levees show this levee height is higher than the opposite side levee height. Red color levees show the reverse situation. At the lowest retarding basin ①, the flow comes only from downstream overflow embankment. At the second lowest retarding basin ②, the flow comes only from Kasumi-tei levee, shown in Figure 11. To other upper retarding basins ③, ④, ⑤, ⑥, ⑦, flood flow comes from the north of Nishi-Ashikari Irrigation Channel. Figure 12 shows a photograph of the confluent point between Higashi-Hira River and Sannou River, corresponding to the retarding basin ⑥ in Figure 11. Both rivers in this area are floodway. There is no house in this area. The area between Kase River and Gion River, a tributary of Kase River is called Wannai, that means inside the bay in spite that this area is far from the coast. There exist 3 type retarding basins for the flood exceeding design levels, which have different purposes each other, and no overlap exist. Protection measures for the villages are considered. Based on the survey of the land tax during the Meiji era in this area, it was found that the land tax was set lower, corresponding to the inundation risk magnitude with fine consideration of this area's characteristics very carefully. This is a typical catchment basin operation.

4. AGAINST INCREASE OF NATURAL DISASTERS DUE TO CLIMATE CHANGE

Natural hazard's magnitude and frequency are estimated to be increased in the future by the effects of climate change, etc. However, resilience against these hazards is estimated to be decreased due to infrastructure's aging, etc. It is necessary to bridge the gap between the increasing hazard's intensity and decreasing resilience. This relationship is explained by Figure 13 as found in Komatsu *et al*. (2015). Against the increase of natural disasters due to climate change, not only the mitigation measures like decreasing the emission of greenhouse effect gas, but also the adaptation measures by many methods in which the traditional flood management technology is one of the robust countermeasures to this problem. It is essential to utilize the past disaster's history and information of topography for natural disasters to suppose every disaster against natural hazards beforehand.

Ohgushi and Kuroiwa (2008) quantitatively estimated the traditional flood management system of the Kase River basin using GIS and 1D flow simulation. A peak discharge of the Kase River's flood occurred in July, 1990 was 1,039m^3/s. This hydrograph was numerically enlarged for the estimation of the peak discharge of 2,500m^3/s (Case A), which was same as the design high water discharge of the Kase River. Moreover, Ohgushi and Kuroiwa (2008) estimated the severe case in which the peak discharge was 3,000m^3/s (Case B). In the Case A, total overflow volume into the retarding basins was estimated to be 506.3×10^4 m^3 On the other hand, the Case B showed $1{,}132.9\times10^4$ m^3 of the total overflowing water volume that was equivalent to the volume of about one seventh of the effective storage volume of Kase River dam. At the present, Kase River dam is used for flood control of this river basin. However, for the future situation like climate change, an additional countermeasure for the future increasing hazard level is necessary. The studied traditional flood management system is considered as one of the solutions for these problems in the future.

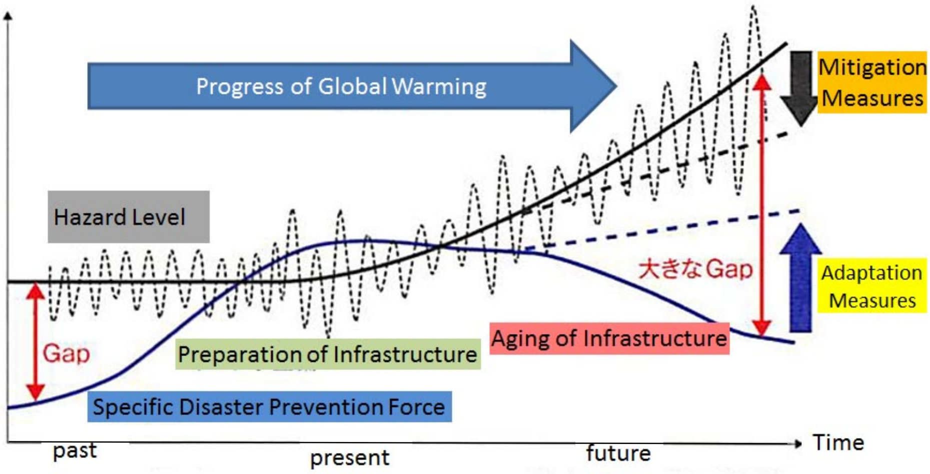


Figure 13 Relationship between hazard level and the specific disaster prevention force (Komatsu, T. *et al.* (2015))

5. CONCLUSIONS

Saga Plain faces on the Ariake Sea, whose tidal range is largest in Japan, so that it is highly challenging to avoid water-related disasters such as floods from upstream and storm surges from downstream. In Saga Plain, main water-related disasters are both torrential rain in rainy season and storm surge due to typhoons. A traditional flood management technology in Saga Plain is a rational technology because the natural condition of the concerned area is fully considered. The traditional flood management technology in Saga Plain is a typical catchment basin operation because the flood flow water is overflowed from the overflow embankment (Nokoshi) on purpose. However, the residential area is protected actively and effectively by the auxiliary levees (Mizuuke-tei). Irrigation channel is used not only for water use but also for flood control and sediment control by the one-side levee channel. There are three types of retarding basins for the flood exceeding design levels, which have different purposes each other, and there is no overlap between each kind of retarding basin. It should be paid attention to this technology as an adaptation measure against the increasing water-related hazards for the future.

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