PAST FLOOD DISASTER DAMAGES AND PAST–FUTURE FLOOD COUNTERMEASURES IN JAPAN

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Abstract

In this report, we first describe Japan's geographical and climate features, then discuss the historical changes in flood damage since 1949, provide details of some major flooding events, then describe the government's current efforts to mitigate damage from flooding disasters, and finally present our research results. We explain that lowland areas are socio-economically important in Japan; that heavy rainfall is becoming more frequent due to the effects of climate change; that flood damage has decreased considerably since 1960, showing the effects of infrastructure; and that although damage to crops has decreased, floods still cause significant damage to agricultural infrastructure. We describe some past heavy rainfall events that resulted in significant human casualties. We explain that, to reduce flood damage further, the government has started a system of "basin flood countermeasures" whereby all concerned parties upstream and downstream of the river basin (central government, local government, municipalities, companies, residents, etc.) work together on flood control measures and the importance of individual decision-making in this system. In terms of our research results, we introduce a program to predict the water level of drainage pumping stations and drainage channels in low-lying areas in real time, based on weather information, etc.

1. Background: A recent situation

1.1. Geological feature

Japan is an island country located in the Pacific Ring of Fire at the eastern end of the Eurasian Continent, and three-quarters of its land area is mountainous. Lowland areas play a significant social and economic role in Japan. The residential demography of Japan categorized by heights above mean sea-level is shown in Fig. 1, based on Sugimoto 2017. Approximately 64 million people, 50% of the population, live in areas that are less than 25 m above mean sea-level elevation. The Ministry of Agriculture, Forestry and Fisheries (MAFF) reports that approximately 32% of agricultural communities live in areas below 30 m mean sea-level elevation (Fig. 2, MAFF, 2016a). The land area below 30 m mean sea-level elevation is less than 12% of the total inhabited land (Fig. 3, Japan Statistic Association, 2007).

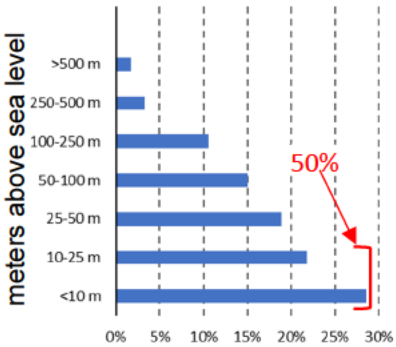

Fig. 1. Residents (2010)

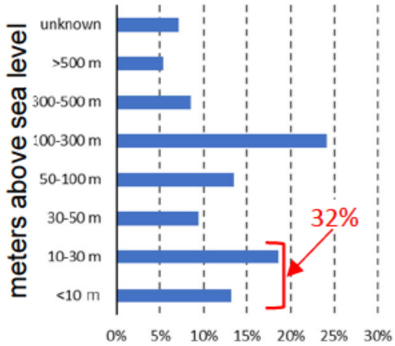

Fig. 2. Agricultural communes (2015)

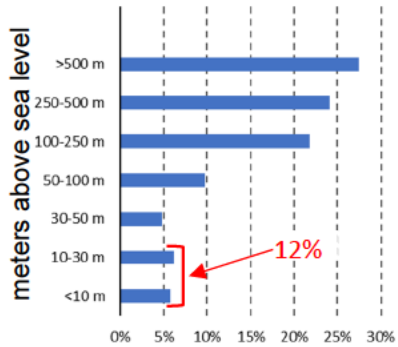

Fig. 3. Japan's land area (2000)

1.2. Climate of Japan

Japan, excluding Hokkaido Island, located in Monsoon Asia, receives relatively high rainfall owing to seasonal rain fronts and typhoons. The annual rainfall received throughout the country is approximately 1,670 mm (MILT, 2019). Therefore, flood control and protection work have been important issues for a

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long time. Accordingly, various types of infrastructure, such as river path changes, river embankments, reservoirs, and discharges have been installed.
The frequency of short-term heavy rainfall of ≥50 mm/h (precipitation in the previous hour at every hour) is increasing (Fig.4, JMA, 2019). The average number of short-term heavy rainfall between 1976 and 1985 was approximately 226 per 1,300 observation points per year; this number increased to approximately 327—about 1.4 times—between 2009 and 2018. In contrast, the number of days with daily precipitation of ≥1.0 mm decreased by 9.3 days per 100 years to approximately 120 days in 2020, considering the statistical period from 1901 to 2020. Thus, the study of climate in Japan has shown an increase in the frequency of heavy rainfall with decreasing number of precipitation days, including days of light rainfall.

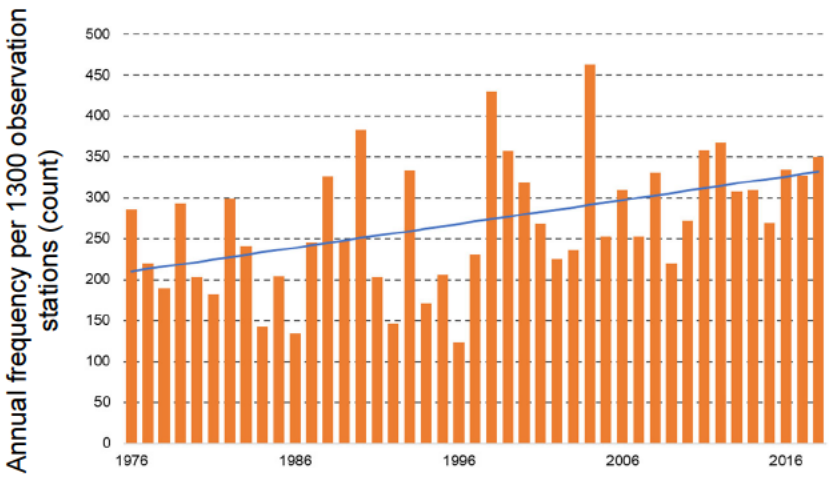

Fig. 4. Annual frequency of over 50 mm/h precipitation in Japan

2. Past flood disasters

Until the 1960s, the casualties from flood and typhoon disasters were extremely high, exceeding 1.66 person per 100,000 people each year*. In particular, the 15th typhoon in 1959 (commonly known as Isewan Typhoon) caused enormous devastation with more than 5,000 dead and missing, thus triggering disaster prevention efforts by the government. In 1961, the Basic Act on Disaster Management was enacted, in which the government decided to actively implement disaster prevention measures and promote comprehensive and systematic disaster prevention policies to protect people's lives and property. The act has contributed to the maintenance of social order, securing of public welfare, and declining of annual disaster casualties to around 100 people.

* Total population: Ministry of Internal Affairs and Communications, 2021.

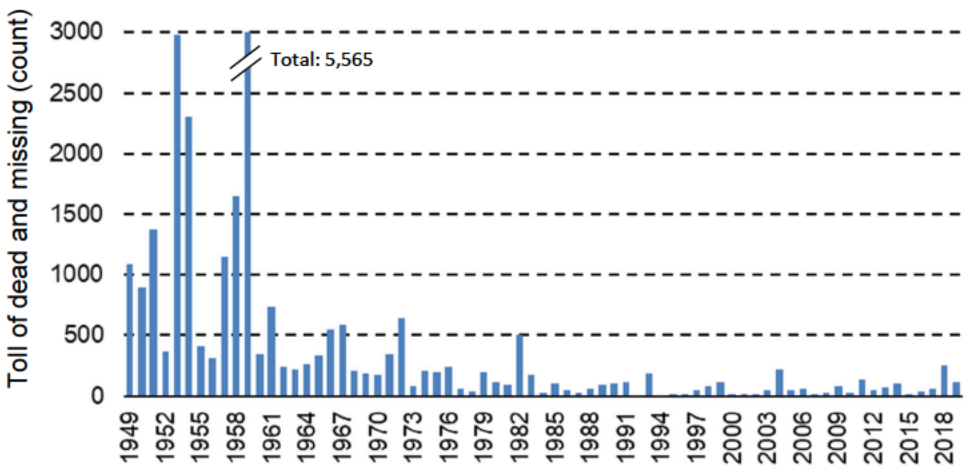

Fig. 5. Annual toll of dead and missing because of flood and typhoon disasters since 1949 in Japan. The toll of dead and missing was calculated with reference to Ushiyama (2017), National Police Agency (1968-2019) and Ministry of Land, Infrastructure, Transport and Tourism (2021).

The agricultural damage caused by flood and typhoon disasters in the last 40 years based on the website of the Ministry of Agriculture, Forestry and Fisheries concerning disasters (MAFF, 2021) is shown in fig. 6. The flood-based damages to agriculture have been increasing, especially in the last four years. Annual agricultural damage caused by flood disasters has mostly exceeded approximately 200 billion JP¥ (equivalent to 1,893 million US dollars at the exchange rate of 105.6 JP¥ per USD as on February 20, 2021), and in 2018 and 2019, it was over 400 billion JP¥. While economic damage to agricultural crop production, which used to be high, has decreased, the damage to agricultural infrastructure, such as ponds, headworks, irrigation-drainage canals, and farm roads, is still high. Such infrastructure play a key role in water circulation and contribute to disaster risk reduction. Therefore, policies and research and development pertaining to disaster risk management must be strengthened.

The solid line with square markers in fig. 6 shows the annual number of deaths and missing persons due to flood and typhoon disasters. In the last 40 years, disasters with death toll exceeding 200 people have been rare. In 2004, several medium-level disasters occurred, leading to a high overall toll of dead and missing. The details of the 1983 and 2018 disasters are presented as follows.

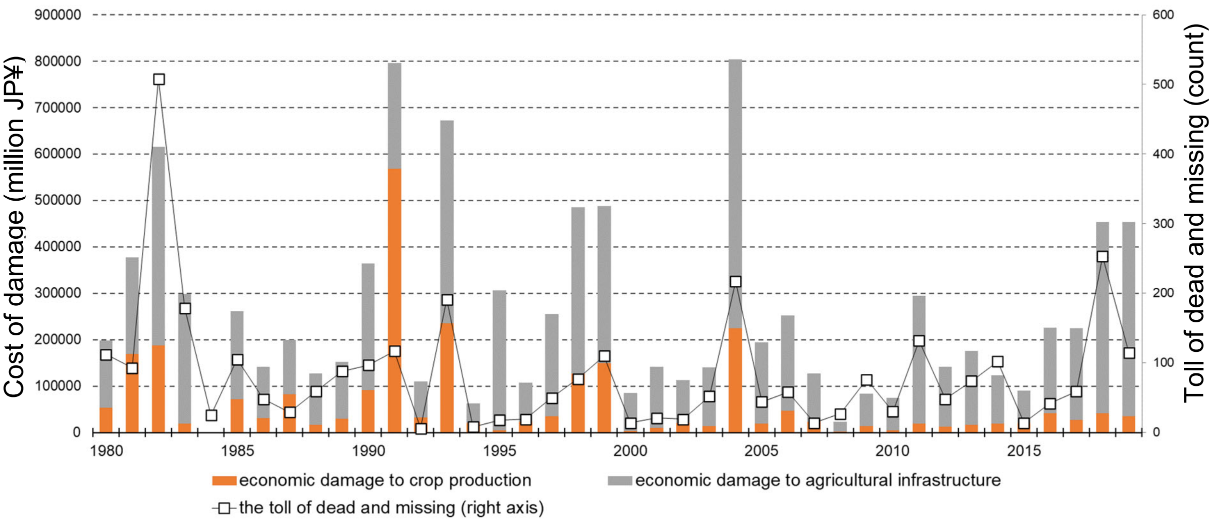

Fig. 6. Damage caused by flood and typhoon disasters

3. Past heavy rainfall events causing major damage

3.1. Isewan Typhoon, 1959 (Showa 34)

The 15th typhoon (commonly known as Isewan Typhoon) made landfall at Shionomisaki shortly after 6 pm on September 26, 1959, with a pressure of 929 hPa. A maximum instantaneous wind speed of 45.7 m/s and a maximum tide level of 5.31 m (Nagoya port) were recorded in Nagoya city. The typhoon caused major storm surge damage from Nagoya city to the coast of Mie prefecture. The daily rainfall from September 26 to 27 was approximately 160 mm in Tsu city, Mie prefecture, equivalent to once in 80 years. Of the 5,098 people reported dead or missing, over 90% were in the three prefectures of Aichi, Mie, and Gifu around the Ise Bay, and 70% of these casualties were due to the storm surge. Over 5,000 people were reported dead or missing, approximately 149,000 homes were destroyed, 158,000 homes flooded, and 5760 levees breached, making it Japan's largest flood disaster of the 20th century. The damage to agricultural land in Aichi prefecture included approximately 1,800 ha of rice paddies covered in debris, approximately 35,000 ha of rice paddies flooded, approximately 1,300 ha of crop fields covered in debris, and approximately 7,700 ha of crop fields flooded (Yamauchi, 1959). The enormous destruction caused by this typhoon prompted the Japanese government to legislate the Disaster Countermeasures Basic Act. Hence, this typhoon is said to be the disaster that shaped Japan's disaster prevention policy.

Fig.7 The photo of Isewan typhoon (Source: Nagoya Municipal Minato Disaster Prevention Center, 2013)

3.2. Nagasaki Flood, July 1982 (Showa 57)

On July 23, 1982, torrential rainfall exceeding 100 mm/h fell for approximately three hours in Nagasaki, causing flooding, landslides, and avalanches of rocks and earth. The daily rainfall in Nagasaki city was 448 mm, equivalent to once in 200 years (Ota, 1983). Nagasaki is a hilly city, and approximately 90% of the 299 casualties died in landslides due to the collapse of slopes. The damage to agriculture and forestry land in Nagasaki prefecture included approximately 2700 ha of agricultural land flooded, buried, or covered in debris; and approximately 20,000 agricultural and forestry facilities damaged. The cost of damage to agricultural facilities, produce, and livestock was approximately 8.4 billion yen (Tanaka et al.1983).

Fig. 8 The photo of Nagasaki flood (Source: Ministry of Land, Infrastructure, Transport and Tourism Kyusyu Regional Development Bureau, 2003a)

3.3. Kagoshima Heavy Rain, 1993 (Heisei 5)

In the afternoon of August 6, 1993, heavy rainfall of up to 99.5 mm/h fell for several hours in the area around Kagoshima city. The banks of three rivers flowing through Kagoshima city burst, flooding approximately 11,000 buildings. The daily rainfall in Kagoshima city was 259 mm, equivalent to once in 200 years (Iwamatsu, 1994). Cliffs alongside the national highway collapsed at 22 points along a 4 km stretch. Approximately 3,000 people were stranded, including drivers of 1,200 vehicles, train passengers, and local residents. In addition, 49 people were reported dead or missing. The soil in this area is known as Shirasu, which is made up of fine volcanic rock and ash; hence, it is susceptible to erosion by rainfall. This is believed to have resulted in the collapse of several slopes. Approximately 800 locations of agricultural land and 1500 agricultural facilities were damaged in Kagoshima prefecture (Yasuda et al. 1994).

Fig. 9 The photo of Kagoshima heavy rain (Ministry of Land, Infrastructure, Transport and Tourism Kyusyu Regional Development Bureau, 2003b)

3.4. July 2018 flood

We report the details of the July 2018 flood (Western Japan flood), which was the worst disaster in the past 30 years, with more than 230 casualties. Two years since the disaster, several findings have been reported from various viewpoints.

3.4.1. Climate condition

Tokyo Climate Center, Japan Meteorological Agency (2018) reported the following:

> Various parts of Japan experienced significant rainfall during the heavy rain event of July 2018 (28th June–8th July), with unprecedented precipitation recorded at some Automated Meteorological Data Acquisition System (AMeDAS) stations of the Japan Meteorological Agency (JMA). During this period, stations in the Shikoku and Tokai regions recorded more than 1,800 and 1,200 mm, respectively (Fig. 7. Some areas experienced two to four times the precipitation of the monthly climatological normal for July (Fig. 10). The overall precipitation reported by 966 selected AMeDAS stations throughout Japan for early July 2018 was the highest for any 10-day period since 1982, highlighting the nationwide significance of this event.
>
> The primary synoptic/meso-scale atmospheric circulation-related factors contributing to the heavy rainfall event detailed in Section 1.1 are as follows (Fig. 11):
>
> (A) ongoing concentrations of two massively moist air streams over western Japan;
> (B) persistence of upward flow associated with the activation of the stationary Baiu front;
> (C) characteristics of line-shaped precipitation systems.
>
> Factors (A) and (B) dominated the event as a whole, while (C) played a significant role in certain areas.

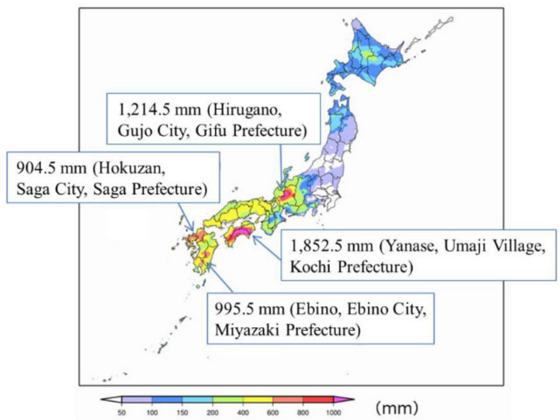

Fig. 10 Total precipitation amounts for the Heavy Rain Event of July 2018 (28th June – 8th July)

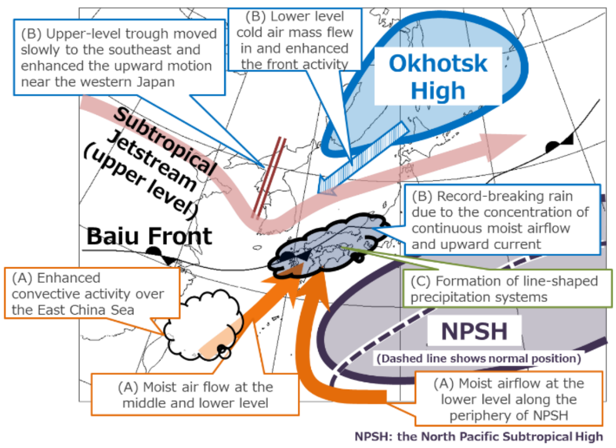

Fig. 11 Primary synoptic-scale motion factors behind record rainfall from western Japan to the Tokai region from 5th to 8th July 2018