# Flood management under climatic variability and its future perspective in Japan

*Tetsuya IKEDA, Junichi YOSHITANI, Akira TERAKAWA*

Secretariat for Preparatory Activities of UNESCO-PWRI Centre,
Public Works Research Institute (PWRI), Tsukuba, Japan

**ABSTRACT**

Devastating magnitudes of flood disasters have been occurring in various areas of Japan, and their impact has been increasing in recent years. Looking ahead, it is foreseen that rainfall and its patterns will be altered due to the climate change accompanied by global warming, and there is concern that the intensity and frequency of flood disasters might be exacerbated.

This paper aims to introduce flood characteristics and management policies in Japan that have been undertaken for a long time in order to mitigate these recurrent flood disasters. It also tries to highlight extremely devastating floods in some areas that occurred under recent climate variability, and to address the progress in the assessment of hydro-meteorological tendencies and in the promotion of dialogue among climatologists and hydrologists. Lastly, a new initiative to establish an international centre on water-related hazards and its risk management is presented.

## 1. Meteorological, topographical and socio-economic conditions of Japan

This part introduces the meteorological, topographical and socio-economic conditions of Japan, and addresses its vulnerability to flood disasters.

(1) Meteorological conditions

Japan is located on the eastern edge of Monsoon Asia and its climate varies according to the seasonal and regional conditions. Typically, heavy rains hit some parts of the country during the rainy season in June-July and during the typhoon season in August-October. Moreover, Japan is often affected by temporary downpours that are locally specific. In winter, snow falls in the northern part of the country, which causes prolonged snowmelt floods in spring. The average annual precipitation is around 1500-1600 mm: Precipitation in Tokyo is twice as much as

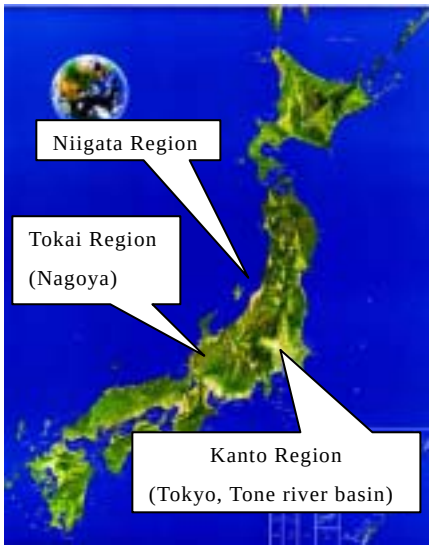



Figure-1: LANDSAT image of Japan

other large cities in western countries. In particular, 50-60% of the annual precipitation in the Pacific coast concentrates from June to October. Due to these meteorological characteristics, flood disasters caused by heavy rains occur frequently in Japan.

(2) Topographical conditions

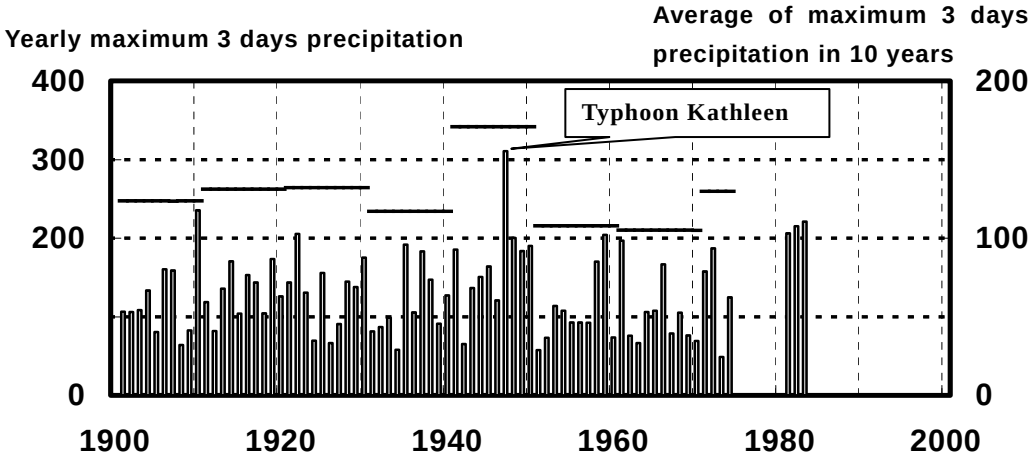
About 70% of the land is mountainous and covered with forests. Due to such topography, rivers in Japan are generally very short and steep, causing flash flooding with high concentrated peak discharge soon after intensified rainfall. The remaining 30% of land is mostly alluvial plains where housing, farming and industries are densely concentrated, consequently increasing the vulnerability to flood disasters.

(3) Socio-economic conditions

Japan has achieved rapid socio-economic development since the end of the Second World War. Its population increased by 50% (from 83 million in 1950 to 127 million in 2000), and the gross domestic product (GDP) increased almost tenfold (from 48 trillion JPY in 1955 to 487 trillion JPY in 2000: equivalent to US$ 4.4 trillion). The majority of the population lives in densely populated areas in downstream alluvial plains, forming mega-cities such as Tokyo and Osaka. Highly valued assets are also concentrated in these urbanized areas. Thus Japan inevitably suffers serious socio-economic damages once flood disasters occur.

## 2. Flood occurrences and management policies

Having such a long history of recurrent flood disasters due to the conditions described above, Japan has developed knowledge and technologies, as well as an adaptive life style to mitigate flood impacts from earlier ages,



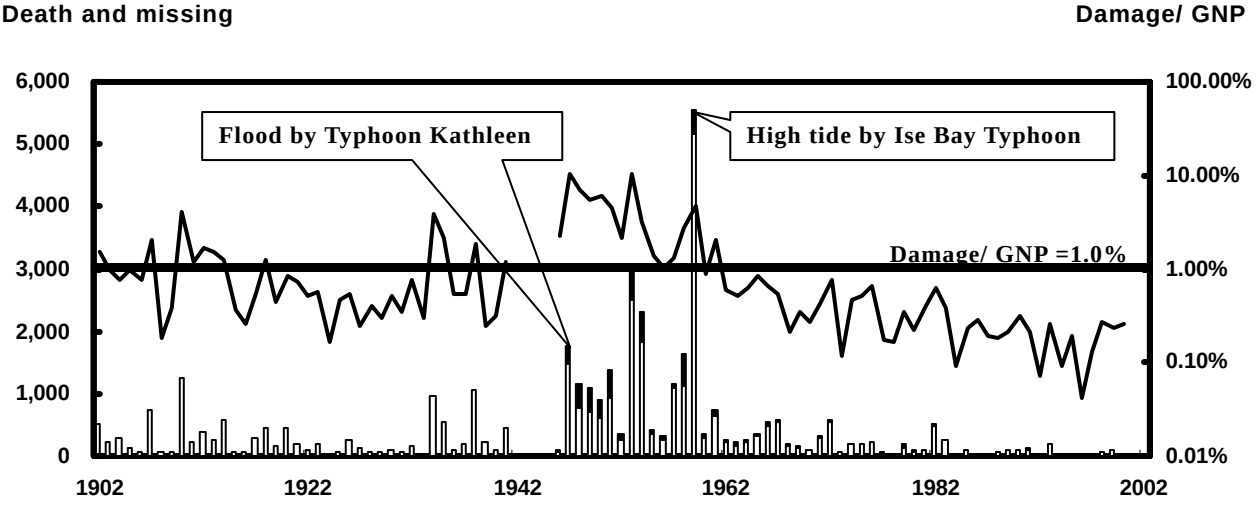

| Decade | 1901 -10 | 1911 -20 | 1921 -30 | 1931 -40 | 1941 -50 | 1951 -60 | 1961 -70 | 1971 -74 | 1975- |
|---|---|---|---|---|---|---|---|---|---|
| (mm) | 124 | 131 | 132 | 117 | 171 | 108 | 105 | 130 | N.A |

Figure-2: Precipitation in the Tone river basin
(Yearly maximum 3 days precipitation upper the Tone river basin from Kurihashi)
(Source: Tone River 100-years Report, Ministry of Construction)

some of which are still effective today. After the modernization of the mid 19th century, the national government started to undertake flood management policies that include river improvement works by importing modern technologies from western countries. Among various floods which affected Japan, a historical one was caused by Typhoon Kathleen in September 1947. The flood hit the war-torn land, breaking the Tone River embankment about 340 m long in the middle reach and causing serious damages in the Kanto region. The floodwater subsequently flashed about 70 km downstream into the central part of Tokyo within two days, bringing about 1,100 deaths and causing economic damage worth US$ 60 million. This flood affected 1.6 million people. Triggered by such catastrophe, the government made tremendous efforts to mitigate flood damages in an integrated manner by continually making investments in flood control works and strengthening its institutional and legislative framework.

Photo-1: Flood in Tokyo due to Typhoon Kathleen

The Ministry of Land, Infrastructure and Transport (MLIT), formerly the Ministry of Construction, has been primarily responsible for flood and drought management policies, and currently manages the 109 main river systems directly, whose basins cover more than 70% of the nation's land, whereas the remaining rivers are managed by prefectural or municipal governments. Under the River Law (established in 1896), each local governmental office conducts river management and flood control works as well as




| Average | 1902-1942 | 1946-1959 | 1960-2002 |
|---|---|---|---|
| Death and missing | 276 | 1509 | 177 |
| Damage (US $ billion) | 1.3 | 11.0 | 6.3 |
| Damage / GNP | 0.92% | 4.43% | 0.38% |

Figure-3: Damage due to water-related disasters (Floods and high tides)

(Source: MLIT)

hydrologic/hydraulic monitoring, relevant studies and river planning. Another legislative framework includes the Flood Fighting Law (established in 1949), which prescribes systematic flood forecasting and early warning in collaboration with meteorological sectors, dissemination of Flood Hazard Maps for the designated rivers, and status and roles of “Flood Fighting Brigades” who conduct flood disaster prevention activities in the community. The flood control works include structural (embankments, flood control dams, flood channels, and regulating reservoirs etc.) and non-structural ones (flood forecasting, early warnings, hazard maps, land use regulations etc.). Although economic damage is still increasing due to socio-economic development and the dense concentration of highly valued assets, such efforts have greatly contributed to the long-term development as is shown from the decreasing trend of the ratio of economic damage to gross national product (GNP). Furthermore the flood-related death toll has dropped significantly since the 1960s.

## 3. Extreme floods under the recent climate variability

Followings are several examples of extreme floods under the recent climate variability, and here tries to examine them from a hydro-meteorological perspective.

(1) Tokai heavy rain in September 2000

A heavy rain hit the Tokai region (Nagoya and its environs), and the daily precipitation (428 mm) was 1/3 of the average annual rainfall for that region. It collapsed river embankments and seriously affected urban functions such as transportation networks and business/ industrial activities. While such a heavy rain is generally anticipated in smaller basins, the simulation on DAD (Depth-Area-Duration) shows DAD curves of the Tokai rain exceeded the maximum curves of Japan in larger areas (over 1000 square kilometers) in particular, which characterizes this extreme flood as record-breaking. (Fukami K, 2003)


Photo-2: Flood of Tokai heavy rain

(2) Niigata-Fukushima heavy rain in July 2004

In July 2004, a seasonal stationary rain front caused heavy rain in the Niigata region, and the daily precipitation reached 421 mm, equal to the average two-months’ precipitation and 20% more

than the maximum rainfall recorded in 1961 (342 mm). Due to this extreme flood, rivers were partially destroyed and muddy floodwater and soil flew into urban areas along the rivers. In this flood 15 people, mostly disabled seniors (over 60 years old), were drowned to death. Inundated houses counted up to more than 26,000. As often the case, this extreme event claimed the lives of those especially vulnerable, and made people realize an urgent need to strengthen the capability to deal with flood emergencies and to improve the existing early warning systems to be more effective.

Photo-3 Niigata-Fukushima Heavy rain
(Sanjo, Niigata)

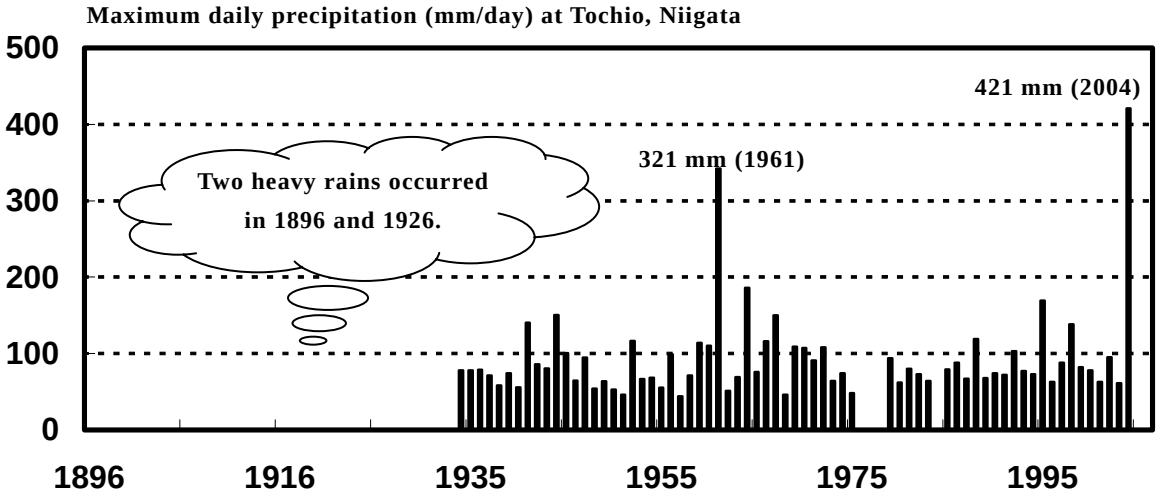



Figure-4: Precipitation of Niigata-Fukushima heavy rain
(Maximum daily precipitation (mm/day) at Tochio, Niigata)
(Source: Japan Meteorological Agency)

(3) Discussion on recent flood disasters

These two floods were record-breaking in a sense that such extreme cases have never been observed since the modernized rain gauge observations began. Some simulations indicate their expectancies are once every several hundred years. However, historical records in the Niigata area indicate that this area has been very vulnerable, suffering frequently from extreme floods every 30-40 years, and so many small-scale floods almost every year. A flood in 1896 claimed 75 lives. In 1926 the total precipitation exceeded 250 mm and more than 100 people were drowned or went missing. In 1961, a heavy rain hit the same area but fortunately it didn't cause such big damages (just three deaths were reported).

The question of whether or not these recent extreme events are caused by the climate change has been raised, but any sufficient evidence to relate them with global warming and its subsequent

climate change is yet to be found. Furthermore it may be pointed out that conventional methods of flood management, which are based on the statistical analysis of the observed data, are no longer applicable if the fundamental conditions, including the climate, are changing. It is safe to say that climate may be changing, but examination of both the long-term precipitation and the history of flood disasters indicates that these catastrophes occur repeatedly, implying that our generation might have just spent "happy days" so far without suffering from such serious extreme flood disasters, which increased vulnerability and fostered a "false sense of safety" as a consequence.

Under such circumstances, managing extreme floods under the current climate variability will help strengthen capabilities and enhance resilience to deal with future climate changes. In order to enhance correct understanding on such extreme hydro-meteorological phenomena, it is essential to develop further assessment studies and to progress advanced researches for accurate prediction by mobilizing/maximizing the available knowledge base. Furthermore, by promoting interactive dialogues among any relevant sectors including climatologists and hydrologists, it is possible to fill the gap of recognition which may exist among them. These attempts will consequently help make societies adaptive to the climate variability of today and of the future.

## 4. Recent progress in the field of flood and climate

(1) Contribution to the Dialogue on Water and Climate

After the 2nd World Water Forum in The Hague, urgent needs were recognized to share knowledge, to foster cooperation and to enhance collaboration among climate and water specialists under increasingly uncertain hydro-meteorological variability and change, leading to create a global Dialogue on Water and Climate. In response to the extremeness of the Tokai heavy rain in 2000, the "Exploratory Committee for climate change influence on flood and drought in East Asia" was established with the participation of researchers and practitioners from meteorological and hydrological fields as well as administrative parties. The Committee actively performed provision cases including the case of the Tokai heavy rain, gathering information about recent research activities, extraction of problems and transmission of information. The Committee also organized an international conference to exchange information among professionals and the general audience. The results of the Committee's activities were presented at a specific session during the 3rd World Water Forum in Japan in March 2003 as one of the significant contributions to the Dialogue on Water and Climate.

(2) Recent progress in the field of flood and climate

Following the 3rd World Water Forum, further progress is being made on rainfall assessment and on future climatic prediction. Research analysis on precipitation data from 1961-2000 reveals the middle term trend of heavy rains at the regional level. Both frequencies and intensities of

heavy rain are increasing in southeastern Japan, and on the contrary, decreasing in the central west. (Yokota S, 2003) Another research focuses on the intensity of rainfall by analyzing the long-term precipitation data in the 20th century. It indicates a tendency for both the number of rainy days and the total annual precipitation to be decreasing. But the decrease in the annual precipitation is not so significant compared to that of numbers of rainy days, which shows evidence of increasingly more intensified rainfalls and longer intervals between rainy days. Other efforts are being made to predict the future climatic trend at the regional level by applying the General Circulation Model (GCM). (MLIT, 2004)

In addition to this progress which has made so far in the scientific field, it is planned to develop the dialogue process as well. Through this dialogue, more hydro-meteorological research findings will be collected together, an increasing number of relevant studies/researches will be developed, and risk communication with the general public will be enhanced by disseminating the scientific findings and delivering right messages on the climate variability and change from the professional point of view.

(3) Initiative to establish the International Centre on Water Hazard and Risk Management

Water-related disasters are occurring in various regions of the world and it is foreseen that their intensity and frequency will be exacerbated due to the climate change in the future. Considering the urgent needs to mitigate them, the Public Works Research Institute (PWRI) is planning to establish an international centre on water related hazards and its risk management under the auspices of UNESCO, making full use of its long accumulated knowledge and experiences in this field. The Centre is planning to promote research, training and information networking activities. The research activities include hydraulic/ hydrologic forecast, observation, and analysis through development of models; management technologies for water-related hazards under various socio-economic, geographic and climatic conditions; identification of the impacts of climate change and the development of its adaptation strategies/ planning. The Center is also designed to contribute to the


Figure-5: Pillar activities of the Centre

Figure-6: Blueprint of the Centre's building

World Water Assessment Programme (WWAP) through expansion of case studies and development of flood indicators, as well as to the UNESCO/ WMO joint International Flood Initiative/ Programme (IFI/P) for its planning and implementation. The Centre is expected to be a central platform to promote research on hydro-meteorological disasters and to develop the dialogue.

## 5. Summary

- Despite its relatively high vulnerability, Japan has achieved much progress in mitigating flood disasters by conducting flood control works and making continuous investments in an integrated manner.
- Recently record-breaking extreme floods have been occurring under the current climate variability, but sufficient evidence to relate them with the climate change is yet to be found.
- Our generation might have just spent "happy days" escaping serious catastrophes so far, which consequently increased vulnerability and fostered a "false sense of safety."
- Managing extreme floods under the current climate variability will help strengthen capability and enhance resilience to deal with future climate changes.
- It is essential to develop hydro-meteorological assessment studies and researches and to promote interactive dialogues between climatologists and hydrologists, which will consequently help make societies adaptive to the climate variability of today and of the future.
- Adding to the progress made so far, a dialogue process is planned to develop. Through this dialogue, further studies and research will be made and risk communication with the general public will be enhanced by delivering right messages. The new international centre to be established in Japan is expected to become a platform for such progress.

## References


Fukami K. (2003): Evaluation of DAD curves of the Tokai Rainstorm in September of 2000, Presentation paper for the 3rd DPRI-IIASA International Symposium, July, 2003, Kyoto, Japan.

Yokota S. (2003): Trend of climatic index, Working paper for the Study team on climate extreme and precipitation, Japan. (in Japanese)

MLIT (2004): Assessment study of the impacts of climate change on water resources, Ministry of Land, Infrastructure and Transport, Tokyo, Japan. (in Japanese)

Exploratory Committee for climate change influence on flood and drought" in East Asia (2003): Session Report for the 3rd World Water Forum on "Climate change influence on flood and drought in East Asia; Effect and response", Exploratory Committee for climate change influence on flood and drought in East Asia, Japan.