Predicting and managing flood risks from extreme rain events in Japan

Extremal rainfall over the Kanto region in 2015 caused heavy flooding across the Kruwagawa River Basin and resulted in fatalities and damage to property. An event on July 5–6, 2017, caused significant flooding in many river basins in Northern Kyushu. The flooding resulted in a significant number of fatalities and property damage. On July 5–8, 2018, torrential rain caused heavy flooding in the Oda river basin, causing severe flood inundation in the Mabicho region of the basin which resulted in significant loss of life and severe infrastructure damage. On October 1–13, 2019, heavy flooding in many river basins in the central-northern region of Japan caused significant loss of life and damage to property. And in the first week of July 2020, heavy rain caused flooding in the southern Japanese island of Kyushu. These events indicate a worrying trend: the damage and associated cost following each event has been increasing. The extent of each flood can be seen on the map in the Figure 1.

Creating better models to understand where and when flooding will occur enables better adaptation and mitigation.

Figure 1. Flooded rivers [1] and their basins during extreme rain events in recent years in Japan.

Figure 2. NIED’s rain simulation facility enables event-specific research.
The case study of Hitoyoshi City determined the areas affected by the July 2020 flood. The rapid-flood inundation mapping product: a flood-inundation tool based on surveying the extent of previous floods which can give real-time flood depth marks in a flooded area. It has a tool to quickly estimate the status of the built environment in an area, to understand what dwellings and critical infrastructure may be at risk during a flood event. The world’s largest rain simulation facility (Figure 2) which elucidates how extreme rain events create sediment problems, such as in landslides, erosion, and flood hydrology. A methodology for using a high-sensitivity seismograph network (Hi-net) to identify the time and peak of water flow in remote ungauged mountainous rivers during heavy rain events. This information is essential for understanding flood risks in river basins during extreme rain events.

Combining these tools gives town planners, engineers, policymakers, and the public substantial insights to make data-driven decisions. Additionally, P.C. and his team are continually building on their process, making new tools and methodologies to create an ever-more comprehensive framework for flood disaster prevention and management. This includes the creation of digital twins (virtual representations of cities or other regions and the flood management systems they have in place) to improve the flood resilience of cities and infrastructure in the future. All the above-mentioned approaches will contribute to these developments.

**FLOOD RESILIENCE MANAGEMENT AND PREDICTION AND ACTION**
P.C. and his team at the NIED have already successfully improved our understanding of flood processes, monitoring, and analysis through multiple pieces of research and case studies. One of these concerns flood inundation mapping of the 2019 event in North Central Japan (Hitachi region), related to the Hagibis Typhoon. The research enabled them to map the greatest of critical infrastructure and human habitation to the flood, making it easier to evaluate and respond effectively. The case study determined the percentages of urban, agricultural, and forest areas affected by the flood, revealing that 5,355 buildings were inundated, and 24% of those buildings were exposed to over two metres of flooding, indicating the highest level of danger (Figure 3). This information will help with real-time flood management, inform future emergency response, and help planners and policymakers understand where to safely position critical infrastructure. This case study will apply to every Japanese city and others worldwide for effective flood-risk response.

**Shakti P.C. and his team at NIED have developed a comprehensive flood-disaster prevention and management framework.**

As just two examples of the many essential research articles and case studies P.C. and the team at NIED have conducted, these studies demonstrate how the outcomes of their research will be integral in contributing to the practice of flood resilience. It will also improve Japan’s town planning and contribute to policies that adapt to current and future catastrophic flooding events caused by extreme rain. P.C.’s work will be applicable globally as climate change brings more frequent, unpredictable, and severe rain everywhere. The team at NIED plan to conduct collaborative research with international universities, companies, and research institutions to further the development and impact of their work and equip countries around the world with the best possible tools and methods to mitigate and adapt to flood-related risks.

**References**

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**Personal Response**

**Could the tools and methodologies you have developed also be effective in predicting and managing flood-related sea-level rises?**

All the developed tools and methodologies can be a useful reference for the warning, response, mitigation, and evaluation process. To improve methods and tools for specific purposes, further research will be performed in the future. There are some promising and important proposals for flood disaster prevention and management during heavy rain events, which are based on interdisciplinary subjects and will be actively promoted going forward. Further collaboration at national and international levels will certainly enhance our research. Sharing experience on flood disasters will help us to tackle this problem globally. Finally, research on extreme rain events and associated floods needs to consider our future climate so that we can enhance flood resilience and adapt to a changing environment.