Forward

What was the Great East Japan Earthquake?

Director, International Research Institute of Disaster Science (IRIDeS)

Fumihiko Imamura

Translated by Catherine Sachi Kikuchi

Summary

Ten years have passed since the Great East Japan Earthquake, which caused unprecedented damage. It was a complex disaster never before experienced by humankind, and there are reports that the impact still exists today. The reality of the disaster, therefore, is still undetermined, yet collaborative research on the disaster and its impact is moving forward. At the International Research Institute for Disaster Science (IRIDeS), we are not only focusing on the traditional natural sciences, but also on the humanities and social sciences, disaster medicine, and health sciences, in order to uncover other aspects of the situation that we do not know, and to explore the essential aspects for disaster prevention and mitigation in the future. The 51 approaches in this book are diverse and we hope they will serve as a basis for disaster science in the future.

Keywords: interdisciplinary research, multi-stage occurrence, complex disaster, tsunami response level, advance recovery

1: Introduction

The earthquake that occurred off the Pacific coast of the Tohoku region at around 2:46 p.m. on March 11, 2011, was named The 2011 Tohoku-Pacific Ocean Earthquake by the Japan Meteorological Agency (JMA), and the disaster caused by this earthquake was named the Great East Japan Earthquake. It was the largest earthquake ever recorded in Japan (moment magnitude (Mw) = 9.0), and the subsequent tsunami spread over a wide area, causing tremendous damage in coastal regions. The images of damage in each place were diverse and complicated, and images of the disaster changed from one moment to the next. It was a complex disaster never before experienced by humankind. It included strong earthquakes, tsunamis, liquefaction, landslides, and fires, as well as the nuclear power plant accident. In the immediate aftermath of the disaster, there were a variety of names for it. Depending on how it was perceived, it was called the Tohoku-Kanto Earthquake, the Great East Japan Earthquake, and the 3.11 Great Earthquake. Today, the most commonly used name is the Great East Japan Earthquake.

2: The Shape of Earthquakes and Tsunamis

Ten years have passed, and images taken at the time of the earthquake and tsunami are becoming clearer. The huge 500 km × 200 km earthquake is estimated to have linked with other characteristic earthquakes in areas of repeating activity and the strain energy that had accumulated for hundreds to thousands of years were released at once. Furthermore, the earthquakes occurred in a multi-stage rupture process from the epicenter (Hasegawa, 2015). The huge tsunami that accompanied the earthquake was also complex. The location of the fault rupture, and thus the tsunami generation, changed with the passage of time. In the northern part of Sanriku, some tsunami waves still cannot be explained by the earthquake alone. In addition to the mechanism of huge and destructive tsunamis, the propagation process lasted for more than two days and included black tsunamis called urban tsunamis, river tsunamis in which the water flows backwards, shrinking and merging of the waves within the cities, tsunami fires, etc. We need to reexamine hazard mapping, evacuation, recovery, and reconstruction based on the reality of these phenomena, now gradually being revealed, which have not been experienced in the past (Imamura, 2015).

3: Process of Damage Occurrence

It is necessary to classify the various aspects of damage caused by the Mw 9.0 mega-earthquake and tsunami into triggers and predisposing factors. Triggers are the natural forces (hazards) that cause disasters (which affect, damage), and predisposing factors are the natural factors related to the nature of the earth's surface, such as topography and ground conditions, as well as the social factors related to humans and society such as population, buildings, and facilities. In the case of tsunamis, triggers are classified into three categories: inundation/crowning, currents, and wave forces. Predisposing factors include coastal topography such as land and sea floors, land use patterns, and protective facilities.

In addition, there are disasters caused by multiple phenomena occurring almost simultaneously or over a period of time. A complex disaster is defined as a disaster in which one disaster event triggers the occurrence of another. This can result in the expansion of the primary disaster, the simultaneous occurrence of multiple disaster events, or the development of a secondary or tertiary fire damage. The images of the disaster seen in the Great East Japan Earthquake is that of a wide-area, complex disaster.

It is also necessary to organize the time scale of disasters. Even now, aftershocks continue to occur, and there is a risk of earthquakes, including induced ones. Although we have yet to return to full normalcy, in addition to the continuing aftershocks, induced earthquakes have occurred, causing damage. Moreover, crustal movement caused by faults and changes (recovery) in coastal topography are affecting reconstruction.

4: Tsunami Response Level 1 and Level 2

In order to prevent a repeat of this tragedy, various efforts have been made to date. These efforts can be organized into risk assessment of low-frequency mega-disasters, enhancement of proactive measures, post-event risk avoidance systems, and efforts to improve resilience. A typical response to tsunamis is the establishment of two tsunami

levels, and I believe that the roles of each level have been organized in the comprehensive tsunami countermeasures (hardware measures such as seawalls, software measures such as evacuation and regional planning). Level 1 is the structural measures to protect human life and communities from tsunamis that occur once every tens to hundreds of years, while Level 2 focuses on non-structural measures and community planning to protect lives from tsunamis of a larger scale.

At the time, in the recovery areas, there were still issues to be addressed in the design of facilities (placement and height of seawalls, etc.), such as how to harmonize safety with the environment and landscape, and how to promote consensus building in the community, but I believe that these issues were the driving force behind the rapid project implementation. However, in the future, it is necessary to discuss not only Level 1 design, but also when and at what stage to implement maintenance (facility protection). The reason for this is that there are many constraints and restrictions within a given project period, and there have been changes in public sentiment and awareness of disaster prevention and safety in the immediate aftermath of this devastating disaster and in the following years. Therefore, it is necessary to discuss reconstruction in advance in unstricken areas, and at this point, I would like to arrange what recovery should look like.

In order to cope with the possibility of a larger-than-expected tsunami (equivalent to Level 2), we need to introduce probabilistic assessments that are not limited to past events, monitor tsunamis in real time, and improve high-precision predictions and evacuation systems. All of these measures are designed to support flexible and resourceful decision-making and action in response to natural disasters, which are always uncertain. This will reinforce self-help and mutual-help in disaster prevention, but it goes without saying that individuals and communities are the main actors and that voluntary efforts are essential.

Conclusion

In the Great East Japan Earthquake, strong earthquakes, liquefaction, landslides, occurred, followed by tsunami inundation and flooding. This resulted in destruction of coastal structures, tidal forests, houses, buildings, and infrastructure, along with topographical changes due to erosion and sedimentation. It destroyed and displaced debris, which led to aquaculture rafts and ships drifting offshore. Furthermore, spills and fires of combustible materials, damage to transportation networks such as roads and railways (including vehicles), and impact on facilities such as nuclear and thermal power plants also occurred. It is thought that the majority of the complex tsunami damage patterns currently presumed to exist took place. Based on the information from natural science, disasters should be considered as an issue within the humanities, social sciences, disaster medicine, and health science. Why did the damage occur? What could have been done at the time? What is needed in the future? While asking these questions, I'd like to summarize and propose future disaster prevention and mitigation. We believe that disasters will continue to evolve, and that the process of their occurrence and spread will become more complex through a chain of events.

The research and publication of this book were supported by the world's top-level research center for disaster science at a designated national university. I would like to express my gratitude to them.

References

Hasegawa, A. (2015). What happened in the source area of the 2011 Tohoku-Oki Earthquake?—The mechanism of the Tohoku-Oki Earthquake. *Earthquake Journal*, 60, 2-15. (in Japanese).

Imamura, F. (2015). Mechanism and damage prediction of giant tsunamis caused by the 2011 Tohoku-Oki Earthquake, *Earthquake Journal*, 60, 16-23. (In Japanese).