Chapter 19
For Deepening of Societal Safety Sciences

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Abstract This summarizing chapter of this book gives a total view of the need for deepening societal safety sciences that the Faculty of Societal Safety Sciences of Kansai University first started. The chapter also looks at the future of societal safety sciences.

The reason why we need deepening of societal safety sciences is because events that concern safety and security of our constantly changing society do not always take places in the same manners. There are cases, of course, of the same damage repeating over; however, the reality keeps exposing us to new types of damages, one after another, that we never had faced before. When faced with them, we often end up only taking passive measures. Deepening societal safety sciences means to make moves ahead of the changing disasters and avoid or reduce the damages so it can contribute to building safe and secure societies.

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19.1 Evolving Natural Disasters

Two major features of natural disasters are their historic nature and regional nature. Historic nature of natural disasters means that the same disaster repeats. As Fig. 19.1 shows, Japan has suffered 99 mega-disaster attacks since the year 500, i.e., at the pace of one every 15 years, each with fatalities of over about 1000. For example, at the ocean bed south of southwest Japan is Nankai Trough running parallel to the coastline with an average depth of 4000 m. There, plate boundary earthquakes with magnitudes of 8 or more have taken place 9 times since the year 684; in other words, they occurred on the average, once every 100–150 years. As the figure shows, each

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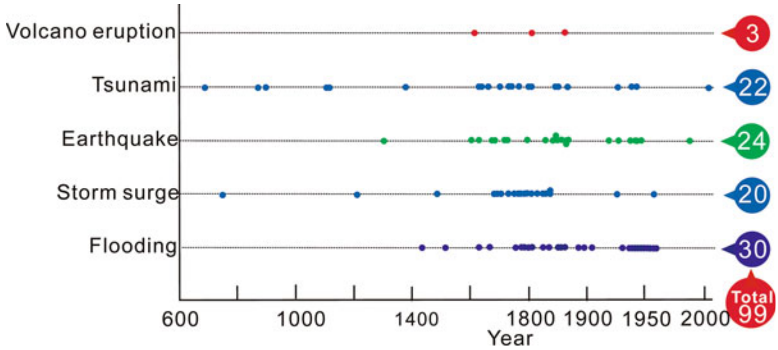

Fig. 19.1 Major natural disasters in Japan (death toll≥1000). (Source: Kawata 2015)

of the four major disasters, earthquake, tsunami, flooding, and storm surge, has taken place 20–30 times throughout our recorded history. And they will continue to do so.

Regional nature of natural disasters means the damages change with different locations. For example, storm surge disasters occur in the Netherlands, the USA, and Bangladesh; however, the forms of damages are quite different. The difference in damages comes from not just different characteristics of the tides but also the suffering societies having different forms.

Natural disasters have characteristics of historic nature and regional nature; however, the forms of damages change with the evolution of the societies. Among the factors that lead to differences, what makes the most difference is the population and its density of the hit area. For example, an avalanche in the woods of Canada with hardly anybody living in there would bring down trees, but the damage is limited. If, on the other hand, an avalanche takes place in the heavy snow area in Japan, a variety of damages come with it in general. The reason is heavy snow areas in Japan have residents that run timber industries, grow fruits, and engage in agriculture and tourist agents that operate ski areas and resorts, and the regions have social infrastructures of roads, railways, electricity, and water supply to support such activities.

Extent of damages caused by disasters depends on magnitudes of natural forces with earthquakes or typhoons and the level of the society's vulnerability in disaster prevention. Let's look at earthquake disasters for an example. Figure 19.2 relates the number of deaths to the earthquake magnitudes with past earthquakes over the world. When an earthquake directly hits a populated area, the death toll is high; however, the number of deaths is small for underpopulated areas. The straight line in the figure shows the maximum death tolls, and if, for example, the earthquake magnitude is 7.3, the danger can cause the number of deaths to reach as high as about 57,000. The Tokyo Metropolitan earthquake feared to take place in the near future will have a magnitude of 7.3 with an estimated death toll of 23,000; however, if the level of social disaster reduction strength falls, the number can possibly go higher. For example, rush hours in the morning or in the evening or the time of 2020 Tokyo Olympics will be when people from in and out of the country are densely

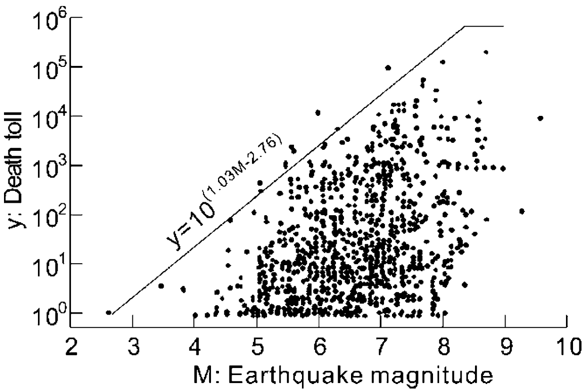

Fig. 19.2 Death tolls vs. earthquake magnitude of earthquakes in the world

packed. Although these hours or timeframes are temporary congestions, we have to pay attention to the undoubted lowered level of disaster prevention strength then.

Next, we will explain how a disaster with constant external strength changes the scenes of damages with the social change of urbanization.

1. Rural disaster: If social infrastructures of electricity, water, communication, railway, and roads are not sufficiently constructed like in farming villages in developing countries, the magnitude of external force and damages to the bodies and social economy are proportional. In Japan, up to the point before the 1923 Great Kanto earthquake, situations with disaster damages were roughly so. The 1896 Great Meiji Sanriku Tsunami took away 22,000 lives; however, there were no measures in place for damage reduction then.
2. Urbanizing disaster: When a city is forming with increase in the residents, if the social infrastructures have not caught up with the growing population, the undeveloped infrastructures cause the disaster damages to go up. The Great Kanto earthquake, for example, caused 105,000 deaths, and 90% of them were killed in fires. The penetration level of waterlines was about 20% back then in Tokyo, and it was difficult to put out the fires in the city. Waterline penetration was still at 26.2% in 1950, and until the late 1970s, after the time of high economic growth, wide area spreading of fires in cities in Japan was typical among other types of disasters. A typical example of an urbanizing disaster in recent years is the 2015 Nepal earthquake that left serious damages in Katmandu. The Third United Nations World Conference on Disaster Reduction was held in the City of Sendai (UNISDR 2015) at around the same time, but if a disaster had broken out in one of the capitals of a developing country like Manila, Bangkok, Jakarta, Dacca, Hanoi, or Yangon, it would have probably shown the scenery of an urbanizing disaster.
3. Urbanized disaster: Once a city is formed and social infrastructure almost complete, a disaster to strike the area causes great damages to the social infrastructures, and the social economic activities will be crippled. The 1978 Miyagi earthquake had a death toll of 28; however, urban life in the City of Sendai, with a population of 650,000 at the time, was paralyzed when gas lines,

waterlines, railway, and other lifelines stopped. The 1994 Northridge earthquake had its epicenter at about 30 km northeast from the center of Los Angeles and caused 57 deaths. The depth of the earthquake source was extremely shallow at 14.6 km, and accelerations over 1 G were felt at several locations. The earthquake tremor destroyed main freeways within 30 km from the epicenter. The traffic, especially, could not go through Santa Monica Freeway with the heaviest traffic in the USA. and the social economic damage amounted to JPY 3.3 trillion (about US $ 30 billion).

4. Urban disaster: When an active fault earthquake takes place in a modern city, bodily and social economic damages reach unprecedented levels. The 1995 Great Hanshin Awaji earthquake that hit the City of Kobe was a typical disaster of this type. About 90% of the roughly 5500 deaths were victims of collapse or falling of old houses. The 2016 Kumamoto earthquake had a direct death count of 50 with collapse or falling of houses; however, the disaster-related deaths reached 213 as of now in June of 2018. There are a number of factors for related deaths; however, the number of related deaths far exceeding the number of direct deaths is a new symptom of urban disasters. By the way, the Kumamoto earthquake caused some level of damages to about 90% of the new and old apartment complex buildings in the City of Kumamoto.
5. Super-urban disaster: The Tokyo Metropolitan earthquake feared to break out in the near future is of this type. In addition to scenes of urban disasters, the capital functions including administration, economics, culture, and so on of the international city Tokyo will be paralyzed, and the social economic damages will propagate throughout the country and are forecasted to give great impacts to the international societies as well. The reason for not implementing any serious measures against direct hit earthquakes under the metropolitan area is due to the deeply rooted perceived notion from experience with the leaders of the government and economics, and ignoring risks of a new type disaster is now a common practice.

19.2 Advancing Societal Safety Sciences to Precede Phenomena

Studies on disaster and accident instantly increase after they actually take place. Social requirements for the studies go up, and at the same time, new data are supplied, and research funds increase as well. We shall, however, not forget that regions and cities change with time, and outbreaks of disasters and accidents produce new damages in addition to the same old damages. For Japan, especially with its aging society, we need to recognize that our power of reducing disasters is dropping.

Table 19.1 shows new academic terms Kawata has defined in preparing academic papers. Kawata proposed many of the terms here before the disasters took place. Once the disaster broke out, many of the phenomena that he had predicted turned into reality. Logical and practical predictions that damages will be magnified or new

Table 19.1 Technical terms by Y. Kawata before the disaster breakouts

Year	Technical term
1986	Disaster evolution, rural/urbanizing/urbanized/urban disaster, disaster culture
1988	Disaster reduction, social vulnerability, soft and hard countermeasure, disaster management
1989	Catastrophic disaster
1995	Compound disaster, acceptable risk, tolerable risk
1998	Vicious cycle of disaster and poverty
2003	Super-extensive disaster (Nankai Trough earthquake), super-urban disaster (Tokyo Metropolitan earthquake)
2005	Worst damage scenario
2008	Ubiquitous disaster reduction society
2010	Survival evacuation, national catastrophe
2013	Phase transition
2015	Disaster resilience, total suitability, displacement disaster
2016	Super-contaminant disaster (Tokyo Metropolitan submergence), compound vulnerability

damages will break out due to social systems weakened against disasters seem hard to understand even for the specialists. The fact that these predictions or forecasts do not reach the central or local governments is regrettable.

In the future, by the way, scenes of disaster will be further complicated, and it will be difficult to distinguish social disasters and natural disasters including accidents. Under such circumstances, we believe damages related to AI or IoT will far surpass others in the future. For example, the state-of-the-art AI technology is concentrated on automated driving, and makers are in serious head-to-head competition about its development. Drivers currently control the automobile; however, once the driving is automated, it will be like riding a "horse" named an automobile. Horses on the road do not collide with trees or power poles on the street and not even with another coming from the other way. When a lightning runs or thunder strikes in the vicinity, a surprised horse will stand on its hind legs and shake the rider off the saddle. We can never say that a similar phenomenon will not happen with automated vehicles. It is the subject for societal safety sciences to find how to secure safety with automatically driven vehicles, or if such safety cannot be secured, or what factors are there that hinder safety. Thus, pursuing the possibility of automated driving at times of disasters, for example, is an important topic.

Table 19.2 summarizes how external force (hazards) from natural disasters over Japan will change in the future. Global warming, currently in progress, will increase the vapor over oceans in tropical areas and intensify the size and strength of tropical depressions like typhoons, cyclones, and hurricanes. Rise of the seawater temperature will make itself clear with increase in rainfall on land. For example, if typhoons of the same size landed on Taiwan and Japan, Taiwan will suffer far more rainfall. The reason is about 2 K higher surface water temperature of the sea that surrounds Taiwan. Also, analysis of data from Automated Meteorological Data Acquisition

Table 19.2 Changes of concern in external force of natural disasters in the future in Japan

Escalation of storm and flood disasters caused by global warming
1. Stronger typhoon with heavier rainfall
2. Frequent locally concentrated rain and guerilla rain
Increased threat of storm surges
1. Continued lifting of seawater level causing higher danger of storm surge
2. Insufficient function with existing disaster reduction facilities
3. Continued land subsidence of artificial islands (e.g., Sakishima in Osaka)
Growing activities of earthquakes and volcanos
1. Earthquakes along Nankai Trough and Tokyo Metropolitan earthquake
2. Active fault earthquakes in inland areas
3. Increase in risk of volcanic eruption including Mt. Fuji

System (AMEDAS) reveals statistically higher frequencies of concentrated rain and guerilla rain.

When tropical depressions like a typhoon intensify, the threat of storm surge disasters is of concern. The tendency was clear with the 2005 hurricane Katrina and 2012 hurricane Sandy that attacked the USA. Concerns of storm surge damages in Japan come from the following three facts: first is the continuing lifting of seawater level. Second is the aging of the tide-control facilities. Areas with frequent storm surge attacks are Tokyo Bay, Ise Bay, and Osaka Bay, and many of the tide-control facilities there were built in the 1960s, i.e., about 60 years have passed since they were built. Storm surges are not just rises of the sea surface, but they come with high ocean waves, and tide-control facilities receive great wave pressure and overtopping. The facilities, thus, require maintenance; however, they have been insufficient. The third reason is the continued land sinking on artificial islands. Sakishima in Suminoe ward in the City of Osaka has been subsiding since its completion in 1980. So far it has subsided, on the average, about 60 cm. The reason is the continued subsiding of the diluvial layer under the alluvial layer. Similar land subsiding is a problem at Kansai International Airport as well. Every year, the terminal buildings are jacked up for the sunken depth, and the runways are taken care of with raising of the seawalls.

Earthquakes and volcanos active now will continue that way until about the year 2100. Subjects of modern scientific disaster analyses have only been disasters that took place within only the past 100 years or so in long human history. We, thus, have to take the risk into account that earthquake tremors or volcanic eruptions that we have never experienced before are possible. Otherwise, if such disasters actually happened, the damages will be devastating.

What we really have to be concerned about is the fact that civil engineering and architecture have set the maximum external force or factors of safety for social infrastructures or buildings based on past experience. Designs of high-rise buildings need aseismic or earthquake-control facilities, and as long as calculated events are within the tolerated performance of them, the designers can add the number of floors and improve the construction cost performance. If, however, the tolerance ranges have been set with maximum external force based on past experience, a major disaster with unprecedented severity may come with an external force that exceeds the tolerance. Today in the center of Tokyo, however, buildings after buildings are on the rise as if they are competing to put up the tallest of them all. We can see that urban development is still going on with priority on economic performance rather than on safety.

19.3 Challenges of Societal Safety Sciences to Accomplish Safe and Secure Societies

The reason for societies to lag behind in their measures for safety and security concerns can be summarized into the following: (1) no measures are taken until actual social problems arise; (2) even when a clue to solving the problem is found, nobody develops it into a solution; and (3) we lack the courage to tackle problems before they break out and make innovative actions.

The above reason (1) may be tolerable for small damages; however, it cannot be ignored with large-scale damages. Environmental pollution that has been a problem with Japan for over 50 some years is a typical example. They first started out locally; however, the delayed countermeasures let them spread throughout the country. Environmental rights to live in a good environment have been catching attention. France has the rights guaranteed for its people in the constitution, and Germany has clearly stated them in its federal laws, and they are enforced. Japan has been discussing about them; however, they have not been established as legal rights yet. For reason (2), we have the following case: When the Great Hanshin Awaji earthquake occurred in 1995, people recognized that geographical information system (GIS) is the key technology in disaster response. In the years that followed, Japan was the leading country in its development; however, our development only concentrated on the hardware and software development of how to make use of the technology was slow. At the end, other countries like the USA took the lead. In terms of reason (3), the sense of responsibility in solving the problems stays at the individual levels. The problems that we are facing or will face about safety and security do not have simple solutions. We need to systematically tackle the problems.

The people of Japan have a hard time understanding the "principle of self-responsibility." The principle of self-responsibility makes an important viewpoint when planning measures to reduce disasters and accidents. To accomplish safe and secure societies, we need to make changes so self and mutual-aid are at the center of the societies.

In analyzing disasters and accidents, we need to look at the societies and their changes in the background with history in mind. It is a pity, however, that there are so many researchers and those responsible that discuss now and the future without knowledge of the past. For example, the concept of disaster measures changed, in response to the changes in the societies, from disaster prevention to disaster reduction and to disaster resilience. The transition means that our view of the suffering social systems changed from part to the whole. When Kumamoto earthquake hit in 2016, the support for the disaster-struck areas targeted total suitability and that was a sign of this change.

Accidents, on the other hand, are called social disasters, and when planning measures against them, we need to evaluate, not just the physical weaknesses of the artificial machines, but we now have to also think about the size of the impact on the societies when an accident breaks out. In fact, social impacts are extremely large with aviation or railway accidents as well as with NPP accidents. Food poisoning and infections are no longer mere regional problems. In terms of problems with the environment, as "An Inconvenient Truth" raised much concern, accident analyses need scientific explanation for their causes and results opened to the public.

To counter and prepare against disasters and accidents, societal safety sciences with combined analysis of natural science and social science need further deepening to meet the target of accomplishing safe and secure societies.

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