Trust: Interdisciplinary Perspectives 2

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Science of Societal Safety

Living at Times of Risks and Disasters

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Preface

The automobile is a convenience of civilization. Accidents that they cause, however, take more than a million lives over the world each year. The Tangshan earthquake in 1976 caused 240,000 to 650,000 deaths in China, and the 2004 Indian Ocean earthquake killed as many as 280,000 people. The 9/11 terrorist attacks in 2001 to the US World Trade Center and Pentagon left about 3000 people dead. Every year, accidents, natural disasters, terror attack, wars, and other causes leave a large number of victims.

Societal safety science aims at preventing accidents and disasters that threaten human societies, reducing the damages caused by such events, rescuing the victims, and promoting recovery and reconstruction of the disaster-struck areas. It is a new field of study that contributes to the enhancement of societal safety through academic fusion of study fields in natural science, social science, and humanities.

International communities have recognized the importance in taking academic approaches to problems in societal safety. Societal safety science, however, has not quite yet established itself as a new field for studying problems in safety. Kansai University, in Osaka, Japan, proposed the field, for the first time, in 2009 and established a faculty and a graduate school with the same title. The facts tell us that societal safety science is a leading field in the studies of disaster prevention. Countries in northern Europe, however, had proposed a similar research field called societal safety in the late 1990s. Our undergraduate and graduate schools use the name societal safety science that attached "sciences" to the title "societal safety."

A new study field needs a sufficient accumulation of researches in the field by specialists. Upon such research accomplishments, the establishment requires publication of an exhaustive and systematic textbook. This book is the first introductory textbook publication for those that study societal safety science for the first time.

When the GDP per capita is small and the country is poor, the societies look to the administration for securing clothing, food, and residence for the people, building infrastructures, and targeting economic growth. For some advanced countries, the years from the end of World War II to the mid-1960s were such times, and the priority was placed on quantitative expansion rather than enhancing quality of living.

Then after the period of high growth, advanced countries accomplished economically wealthy societies in the latter half of the 1960s. After the oil shock, infrastructures like roads and highways, water supply and sewage, and housing matured, and then the social demands turned their interests to quality than quantity and securing safety for the people. In the academia, Ulrich Beck published *Risk Society* (SAGE Publications Ltd., 1992) and discussed that modern societies forced to emphasize production and distribution risks instead of those of wealth, and James Reason, well known in the field of accident theory, published *Managing the Risks of Organizational Accidents* (Ashgate, 1997).

As we described above, Kansai University, for the first time in Japan, opened the Faculty of Societal Safety Sciences and the Graduate School of Societal Safety Sciences in 2010. A 2000 report "For the Establishment of Safety Sciences" by the Science Council of Japan contributed to the idea of building a new faculty. The report stated:

> "Safety Engineering has made great accomplishments for realizing safety through engineering efforts. Simple engineering efforts, however, are now facing difficulties in dealing with the enormous sizes of technical products and globalization of our living environments. We now need to establish a field of Safety Sciences to counter safety problems from a wider standpoint beyond simple engineering approaches."

This book of 5 parts and 19 chapters is the English edition of our book published in Japanese in March 2018 from Minerva Shobo. Part I "Human Societies and Societal Safety Sciences" gives overviews of what societal safety sciences aim at, development of scientific technologies and changes in human societies, how people are coping with risks in the modern societies, and how safety engineering and studies of disaster prevention and risk management developed. Part II "Events that Threaten Human and Its Societies" explains natural and social disasters and their histories, environmental risks, wars, crimes, and terrorisms. Part III "Risk Analysis and Management" discusses problems related to risk, like methods of risk analysis, risk management, risk communication, crisis management, and so on. Part IV "Social Mechanisms for Disaster Management" analyzes public systems for disaster prevention, reduction, and mitigation, government activities for disaster management, private systems for such purposes, and systems for supporting disaster victims. Part V "For Advancement of Societal Safety Sciences," in the end, discusses the future of societal safety sciences through governance and agreement formation for societal safety.

Societal safety sciences tackle a big diversity of problems including natural disasters, accidents, environmental destruction, food safety, illnesses including pandemics, crimes and international terrorism, and information security. Translating this book into English, therefore, is only successful with not just high abilities in English as a language but also through work by someone with skills and knowledge to understand these problems in their own special fields. The translator of this book, Dr. Kenji Iino, met the task beautifully.

This book is the first systematic textbook in societal safety sciences. The authors will be greatly delighted if it spreads internationally and helps the world make steps forward in building safer societies.

Finally, we would like to express our gratitude to Professor Takashi Inoguchi for his valuable suggestions in publishing this book. We are also grateful to Springer Japan and Minerva Shobo for allowing the publication of the English version *Science of Societal Safety: Living at Times of Risks and Disasters* of the Japanese book *Shakai Anzengaku Nyumon*.

Takatsuki, Osaka, Japan
September 1, 2018

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Abbreviations

AI	Artificial intelligence
AIDS	Acquired immunodeficiency syndrome
AMEDAS	Automated meteorological data acquisition system
BCP	Business continuity plan
CAA	Consumer Affairs Agency, Government of Japan
CAO	Cabinet Office of the Government of Japan
CIV	Crisis impact value
COP	Conference of the Parties
COSO	Committee of Sponsoring Organizations of the Treadway Commission
CSR	Corporate social responsibility
DDT	Dichlorodiphenyltrichloroethane
DMAT	Disaster medical assistance team
DHS	US Department of Homeland Security
ERM	Enterprise risk management
FAO	Food and Agriculture Organization of the United Nations
FDMA	Fire and Disaster Management Agency of Ministry of Internal Affairs and Communications, Government of Japan
FEMA	Federal Emergency Management Agency
GCP	Good clinical practice
GDP	Gross domestic product
GIAJ	General Insurance Association of Japan
GIROJ	General Insurance Rating Organization of Japan
GIS	Geographical information system
GLP	Good laboratory practice
GMP	Good manufacturing practice
GPS	Global positioning system
GTD	Global Terrorism Database
HERP	Headquarters for Earthquake Research Promotion
HIV	Human immunodeficiency virus
HLW	High-level radioactive waste

IAEA	International Atomic Energy Agency
ICAO	International Civil Aviation Organization
ICE	Intercontinental express
ICRP	International Commission on Radiological Protection
ICS	Incident command system
ICT	Information and communication technology
IEC	International Electrotechnical Commission
ILO	International Labour Office
IoT	Internet of things
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
ITS	Intelligent transportation systems
ITSA	International Transportation Safety Association
ITU	International Telecommunication Union
JIS	Japanese Industrial Standards
JISC	Japanese Industrial Standards Committee
JLSC	Japan Legal Support Center
JR	Japan Railways
JTSB	Japan Transport Safety Board
LCC	Life-cycle cost
LIAJ	Life Insurance Association of Japan
METI	Ministry of Economy, Trade and Industry, Government of Japan
MEXT	Ministry of Education, Culture, Sports, Science and Technology, Government of Japan
MHLW	Ministry of Health, Labour and Welfare, Government of Japan
MIC	Ministry of Internal Affairs and Communications, Government of Japan
MLIT	Ministry of Land, Infrastructure, Transport and Tourism, Government of Japan
MOD	Ministry of Defense, Government of Japan
MOE	Ministry of the Environment, Government of Japan
NCPTSD	National Center for Posttraumatic Stress Disorder, US Department of Veterans Affairs
NCTSN	National Child Traumatic Stress Network
NILIM	National Institute for Land and Infrastructure Management
NIMBY	Not in my backyard
NOx	Nitrogen oxides
NPO	Nonprofit organization
NPP	Nuclear power plant
NRC	US Nuclear Regulatory Commission
NTSB	National Transportation Safety Board
OSHMS	Occupational safety and health management systems
PCB	Polychlorinated biphenyl
PDCA	Plan, do, check, act

PFA	Psychological first aid
PM	Particle matter
PRA	Probabilistic risk assessment
PRTR	Pollutant release and transfer register
PTSD	Posttraumatic stress disorder
SARS	Severe acute respiratory syndrome
SCJ	Science Council of Japan
SPR	Skills for psychological recovery
SSJ	Seismological Society of Japan
TB	Tuberculosis
TBT	Technical barriers to trade
TEPCO	Tokyo Electric Power Company
TMI	Three Mile Island
UNEP	United Nations Environment Programme
UNISDR	United Nations Office for Disaster Risk Reduction
UNODC	United Nations Office on Drugs and Crime
USACE	US Army Corps of Engineers
VC	Volunteer center
WHO	World Health Organization
WTO	World Trade Organization

Part I
Human Societies and Societal Safety Sciences

Chapter 1
What Do Societal Safety Sciences Aim at?

Seiji Abe, Mamoru Ozawa, and Hideyuki Shiroshita

Abstract Societal safety sciences are new academic systems of interdisciplinary studies that combine specialized fields of social science and humanity in addition to those of science and technology for the purposes of preventing accidents and disasters that threaten human society, containing their severity and frequencies, reducing damages, rescuing the victims, and recovering and reconstructing the disaster areas. This chapter explains the position of societal safety sciences in issues related to our safety and outlines their methodologies and scopes.

Keywords Accident · Disaster · Incident · Risk · Societal safety

1.1 Is the Unexpected and the Unpredictable on the Steady Increase in the Twenty-First Century?

1.1.1 Unexpected Accidents

Every person wants to lead a safe and happy life. Advancements in science and technology have made our society convenient and comfortable. On the other hand, however, a variety of accidents and events take place to threaten our safety.

About 1.3 million people (2015) die annually in Japan. The Japan Ministry of Health, Labour and Welfare (MHLW) published in its "2017 Vital Statistics of Japan" (MHLW 2017) that the first cause of death was malignant neoplasms (cancer) followed by heart disease in the second place, then by other diseases of pneumonia, and cerebrovascular disease. Among the causes of death, "unexpected accident" ranks number six or so each year.

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Unexpected accidents are causes of death listed in the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10. Version 2010) by the World Health Organization (WHO) including "transport accidents"; "accidental suffocation"; "slipping, tripping, stumbling, and falls"; "accidental drowning and submersion"; and so on (WHO 2010). The death toll due to unexpected accidents include victims of earthquakes or tsunami and those who died of food poisoning during their normal lives, and the total figure reached as high as 38,306 in 2015. In other words, among annual deaths in Japan, about three out of a hundred are due to unexpected accidents. As we will explain later, unexpected accidents in societal safety sciences are not just natural disasters or accidents, but they also include a wide range of events like terrorism, war, influenza pandemics, and drug toxicity. Reducing the number of deaths caused by unexpected accidents is one of the primary targets of societal safety sciences.

MHLW translated "transport accidents" by WHO to the Japanese phrase "traffic accidents" commonly used narrowly for accidents involving automobiles (traffic accidents on roads). The wide meaning of traffic accidents in Japan also includes those with railway, aircraft, and watercraft. "Vital Statistics of Japan" by MHLW uses the phrase "traffic accident" in this wide sense. In this book, we use the word traffic accidents to mean automobile accidents in the narrow sense and stick to the original phrase by WHO "transport accidents" for all transportation-related accidents including automobiles.

The historic transition of deaths due to unexpected accidents shows an annual count about 20,000, i.e., about 2% of the total deaths, in the late 1800s to the early 1930s but jumped above 30,000 before World War II. During the high-growth period of the mid-1950s to mid-1970s, the large number of traffic accidents pushed the deaths by unexpected accidents up, and in the mid-1960s to the early 1970s, the count exceeded 40,000. In the mid-1970s to the early 1990s, the number dropped to about 30,000; however, it came back up to about 40,000 in the later 1990s and has stayed at this level till today.

The current death count of about 40,000 annually seems significantly larger than the 20,000 in the late 1800s to the early 1930s; however, we must recognize that the population back then was about 40–50 million, i.e., less than half of our population now. The ratio of deaths due to unexpected accidents among the total death count, however, at about 3% now is much higher than the 2% back then. The higher rate is probably due to the large number of post-World War II transport accidents including traffic accidents that were almost none back then.

A major natural disaster temporarily boosts up the deaths caused by unexpected accidents high. In fact, the year of the Great Kanto earthquake, 1923, saw 71,322, about 2.8 times the number in the previous year; the year 1995 of the Great Hanshin-Awaji earthquake marked 45,323, a little over 9200 more than the previous year; and 2011 with the Great East Japan earthquake had a sudden increase of over 20,000, compared to other years, leaving 59,416 dead.

1.1.2 Unexpected Accidents and Societal Safety

In 2010, MHLW published "Mortality Statistics from Accidents" with detailed analysis of unexpected accidents from 1995 to 2008 (MHLW 2010). It was the second publication of this type following the 1984"Mortality Statistics from Accidents and Adverse Effects." These statistical data are effective in understanding the detail of unexpected accidents.

Reviewing the accidental deaths in 2008 by type, "suffocation" by, for example, choking on food, ranked first with 9419. Then "traffic accident (transport accident)" at 7499, "fall" at 7170, and "drowning" at 6466 followed. These four types of accidents caused over 70% of the total number of accidental deaths. Other accidental death types in 2008 were 1452 due to "smoke inhalation or exposure to fire" and 895 caused by "poisoning from or exposure to hazardous material."

During post-War Japan, transport accidents stayed at the first type of cause of accidental deaths for an extended time. At its peak in 1970, the transport accident deaths exceeded 20,000 annually, amounting to 55% of the entire count. Today, the number of traffic accident caused deaths has dropped significantly to about 1/3 of the number back then.

In general, transport accidents occur away from home; however, about 40% of accidents of deaths of other types take place in home, and about 80% of those victims are elderlies at 65 or over. The breakdown of types of in-house accidental deaths was 85.3% fire, 63.1% drowning (mostly in bathtubs), 58.2% poisoning, 42.4% suffocation, and 35.7% falls. These numbers indicate that home, where safety and security have to be assured, is, in fact, the place where the biggest dangers hide.

By the way, some point out that the numbers of accidental deaths in MHLW's statistics are underestimated and that they should be greater in reality. For example, the real number of accidents during medical treatment is unknown and such type of death counts is unknown. The real number of accidental deaths may well exceed 40,000; however, published data from MHLW make a certain powerful measure for evaluating the degree of societal safety.

1.2 Alleviating and Living with Disasters?

1.2.1 Purpose of Societal Safety Sciences

As we live our daily lives, we are surrounded by a number of possible hazards including earthquake, transport accidents, fires, food poisoning, environmental contamination, and health disorders.

If we look around us, there are a great number of highly capable and complex industrial products. We take the high convenience these products offer for granted without knowing their detailed structures or operational principles. Machines, however, fail. Some industrial products, like an automobile, can turn into a deadly weapon if we mishandle them. Once an industrial product has some kind of failure, in the worst case, we may not only lose our lives, but it can cause damage to lives and properties of others.

The 1995 Great Hanshin-Awaji earthquake and the 2011 Great East Japan earthquake took away large numbers of lives and properties, and they destroyed the infrastructures. During the Great East Japan earthquake, tsunami waves attacked the Tokyo Electric Power Company-owned Fukushima Daiichi Nuclear Power Plant (NPP), and loss of the nuclear reactor core cooling function led to devastating core meltdowns. We have been repeatedly exposed to disasters caused by natural phenomena, that we have no control over, like earthquakes, tsunami, typhoons, and torrential rain. Japan is a "country of earthquakes" with about 20% of all magnitude 6 or bigger earthquakes in the world occurring in and around Japan.

Industrial products, various machinery and apparatus are called artificial products. In general, events that cause bodily injury or property damage are "accidents." When sizes and capacities of artificial products are large, the magnitudes of suffering grow accordingly.

James Reason categorized accidents into two types: an "individual accident" that causes effects only on individuals and an "organizational accident" that affects the entire organization or the society (Reason 1997).

On the other hand, damages caused by natural phenomena like earthquakes or typhoons are generally called "natural disasters." We call accidents that take place while at work "labor accidents." In Japan, we sometimes call such accidents "industrial disasters," that is, to call an accident a disaster. In Europe and the USA, they are called work accidents or occupational accidents.

The purposes of "societal safety sciences" involve preventing accidents and disasters that threaten human society from occurring, controlling their magnitudes and frequencies, reducing damages caused, saving the victims, and promoting recovery and reconstruction of disaster-struck areas. Problems that societal safety sciences face are all not simple with complex facets. For analyzing the processes and recommending policies for resolving and improving problems, as we will detail later, we need interdisciplinary approaches that combine not only the fields of engineering, but also specialized fields of law, economics, sociology, psychology, science, information technology, social and occupational medicine, and all.

1.2.2 Hazards, Incidents, Accidents, and Disasters

Physical or chemical factors or dangerous sources that cause accidents or disasters are called "hazards." Earthquake hazards, for example, are the inter-plate forces. The hazard of poisoning accidents from incomplete combustion is carbon monoxide

(CO) produced during combustion processes. Whether a hazard directly or indirectly causes damage to humans or the society depends on its size, strength, environment, and intervention with social organizations or human.

An "incident" is an event of temporary minor damage to human, society, or an organization caused by a hazard. Incidents include narrow escapes that are worth investigating their causes (Reason 2008) to events of major damages like human death or injury or loss of property values caused by not avoiding such critical crises. When, especially, damages to people or their properties are serious, we call such cases accidents. For example, a near miss between airplanes is an incident because there were no human or physical damage, whereas, if they actually collide, it is an accident. Accidents vary in their magnitudes from small ones to those that lead to hundreds of victims. Especially, NPP accidents that spatially affect wide areas for extended long times are sometimes called mega-accidents or mega-disasters.

As we will discuss in Chap. 6, suffering and damages to the human society caused by natural phenomena are called "natural disasters." This book, in contrast, calls human-caused disasters, like aviation accidents, NPP accidents, or major explosions, "social disasters." The phrase social disaster has a different meaning in English, and in Europe and the USA, such accidents are called "man-made disasters."

A disaster that affects a nation, beyond what a social organization can handle, is called a "mega-disaster." When the disaster causes huge sorrow and destruction to the society, we sometimes call such an event a "catastrophe."

1.2.3 Reducing and Coping with Risks?

Hazards, whether they affect us or not, are always around us. They are hard to control and suppress in case of natural disasters. Preparatory actions to prevent incidents causing hazards from developing into accidents or disasters are "disaster prevention," and suppressing the severity and spread of damages after accidents or disasters that have taken place is called "disaster mitigation." For example, setting automatic train stops (ATS) on railways are acts of disaster prevention to prevent collision or derailing. Seatbelts and airbags in cars are types of disaster mitigation for reducing the severity of human suffering in case of collision accidents.

Human and material resources our societies possess are finite. In modern society, social agreements determine where and how to distribute the resources. These agreements take certain quantitative scales for their settlements. "Risk" is one of the concepts that affect these agreements. The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) define risk as the "effect of uncertainty on objectives" (ISO/IEC 2014). Risk is a quantitative measure that depends on projected magnitudes of damages and their probabilities of occurrence. Risk is the sum of products of the magnitude and chance of events; however, in some cases it is determined just by the size of damage or frequency.

ISO further defines "safety" to mean freedom from intolerable risk. Here, freedom from intolerable risk does not necessarily mean zero risk, but it evaluates minor dangers as risk and, however in turn, allows certain level of risk (Slovic et al. 2000). The society determines the tolerable range of risk which varies depending on time and cases.

Direct comparison of different measures is difficult. Risk is a method of relative evaluation among a variety of measures. "Risk assessment" is the safety of systems or their parts by, for example, identifying relative weaknesses. There are two types of risk assessment: "deterministic risk assessment" and "probabilistic risk assessment" (Lee and McCormick 2011).

Deterministic risk assessment qualitatively evaluates risks of accidents and disasters with conformance or other qualities to safety standards. Probabilistic risk assessment, on the other hand, evaluates risks associated with a system or its specific part with all scenarios that lead to accidents or disasters from hazards by calculation based on reliabilities of parts, elements, and operator interventions related to each scenario. Probabilistic risk assessment is often used for evaluating risks with complex systems like NPPs or airplanes.

Scenarios in probabilistic risk assessment are generally called an "event tree." The safety and reliability of an entire system largely depend on probabilistic reliability of each elements of the system as well as the construct of the event tree. Probabilistic risk assessment, thus, requires evaluating errors, that is, the uncertainty evaluation of the risk assessment itself. In that sense, probabilistic risk assessment works well in identifying weaknesses of a system instead of as a tool in evaluating the safety of an entire system.

1.3 Building Safe and Secure Society Together

1.3.1 Events That Threaten Human and Examining Them

We do not call a tsunami attack on a deserted island a disaster. The same applies to a major avalanche in an uninhabited forest area. When the event affects people or the society, it is an accident and a disaster.

Figure 1.1 shows issues that societal safety sciences handle among problems that pose threats to people or their societies. They cover a large variety from accidents and natural disasters to terrorism and wars. In facing these issues, we have to not only analyze the characteristics, features, and structures of them but also have to propose policies to resolve and improve them.

We cannot select or control sizes or regions of natural disasters, like torrential rain; thus, we need to quickly evacuate disaster-struck areas to avoid dangers. Nevertheless, no matter how urgent the situation may be, whether the people actually

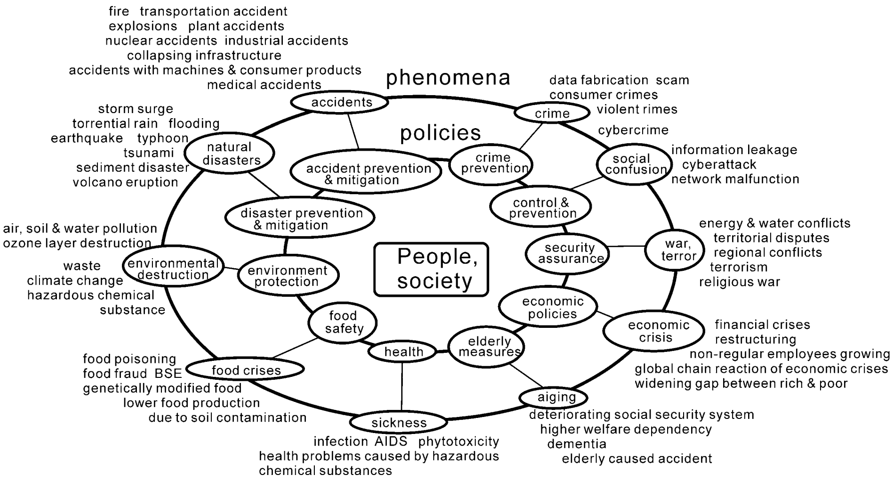

Fig. 1.1 Topics in societal safety science

evacuate the area or not depends on past individual experiences and their psychological states. Quite a number of people, in fact, ignore evacuation orders by local administration offices. Such reality suggests that authorities have to consider psychological factors in deciding whether to enforce evacuation. On the other hand, matters for saving disaster victims and supporting reconstruction of disaster-struck areas relate to socioeconomic evaluation, legal systems, and financial constraints; thus, they require approaches from economics and public administration.

Preparing against a large-scale tsunami disaster, like the one that hit during the Great East Japan earthquake, takes an enormous amount of budget for hardware preparation. If we want to reduce the hardware preparation cost, we have to build software measures, like educating the residents about disaster prevention and clarifying the evacuation routes, and, at the same time, prepare improved systems for resident notification and develop procedures for helping those that require assistance. Such preparations require not just engineering knowledge but also specialized knowledge over a wide range of specialties. The same applies to accidents as well. Airplanes are means of transportation through the air, and damage to their engines or fuselages caused by aging, poor maintenance or bird strikes, as well as stalls due to pilot error or turbulence can immediately lead to their falls. Preparing against them means to have knowledge in not only aviation engineering, mechanical engineering, and human engineering but additionally in biology for countering bird strikes and public administration for safety regulations. Dealing with problems that surround societal safety, thus, requires not only revealing the physical and chemical mechanisms of accidents and disasters but also studying human, social, and economic environments that the problems relate to.

1.3.2 Societal Safety Sciences as a Field of Synthetic Science

Conventionally, academic fields that study natural disasters include civil engineering and architecture, and those that study accidents and industrial safety are engineering fields of mechanical, chemical, safety, and so on. All these specialized fields handle disaster and safety issues with engineering methodologies. In modern days, complex and diversified problems in safety revealed limitations with such engineering approaches alone. Yoichiro Murakami advocated “safety studies” (Murakami 1998) to cover a wide range of safety issues including drug toxicity, medical accidents, and food safety in addition to those industrial safety concerns like nuclear accidents. In fact, the Science Council of Japan (SCJ), in February of 2000, published the following recommendation (SCJ 2000). “Safety engineering has made large contributions in realizing safety from engineering standpoints. With such changes, however, of our technology growing much larger and our living environment globalizing, simple engineering analytic approaches alone are facing difficulty in handling safety problems. We now need to construct “safety studies,” an academic field that deals with safety problems from a wide viewpoint beyond the conventional scope of safety engineering.”

Various problems within nature, our environment, artificial structures, and functions cause accidents and disasters. These problems turn into incidents following some physical or chemical laws and finally break out. We also design and manufacture artificial products following some physical or chemical laws; however, before they enter the market as industrial products, factory workers and organizational activities of quality and value evaluation affect them. Solving societal safety problems that relate to people’s safety and security, thus, requires multi-angled viewpoints over a synthetic framework that covers human, society, scientific technology, and nature.

Societal safety sciences offer a new multi-angled integrated field of study about safety and security. Technical prevention and mitigation of disasters are insufficient for building a safe and secure society. This study has to involve regulation by standardizing artificial products, provide compensation through insurance if human and physical damages are foreseen, and also look into saving victims as well as regional recovery and reconstruction. In contrast to safety engineering that empathizes safety measures, societal safety sciences not only study accidents and disasters, but form a synthetic field of science that comprehensively and practically approaches common social and economic effects and their mitigation caused by such accidents and disasters.

1.3.3 Methodologies and Problems with Societal Safety Sciences

Kansai University advocated societal safety sciences in 2009 and, to promote research and education in the field, established new Faculty of Societal Safety Sciences and the Graduate School of Societal Safety Sciences. For reducing disasters and mitigating the damages to the minimum, we need to first understand their risks and then establish policies and systems to prepare against them. The Graduate School of Societal Safety Sciences at Kansai University is actively involved with research and education of disaster prevention and mitigation, i.e., disaster management, with three basic fields of science and engineering systems, societal systems, and humanities systems.

The science and engineering systems consist of fields in science and engineering that contribute to preventing and mitigating disasters by clarifying their mechanisms. Conventional academic fields they cover are earth science, system engineering, civil engineering, mathematics, and so on. Societal systems cover administrative policies about disasters and damages, their underlying laws, economics and operations, social system design, and so on. Conventional academic fields they involve are law, public administration, economics, operations research, public health, and so on. Finally, humanities systems handle the psychology and ethics of people in disasters and victims, people-to-people and people-to-society communications, and so on. Corresponding conventional academic fields are psychology, theory of communication, sociology, ethics, and so on. We designed our schools for these three areas to overlap and synthesize with overlaps instead of having exclusive visions.

As we can see from the establishment of the Integrated Disaster Risk Management (IDRiM) Society, the importance of an integrated approach to safety-related problems is a globally recognized movement. Societal safety sciences, however, is not an internationally recognized academic field of “new safety studies.” Kansai University first advocated it in 2009 and built a faculty with the name in 2010. Societal safety science is a new academic field born in Japan.

Some countries in northern Europe gave birth to a research field, in the late 1990s, with the name “Societal Safety” with scopes similar to those of societal safety sciences. When Kansai University writes societal safety sciences in English, it uses the phrase Societal Safety.

Researchers concerned with safety all recognize the need for an interdisciplinary approach to handle problems in the field. Researches about safety in Europe and the USA merely cross existing academic fields. If we describe these methods with trees,

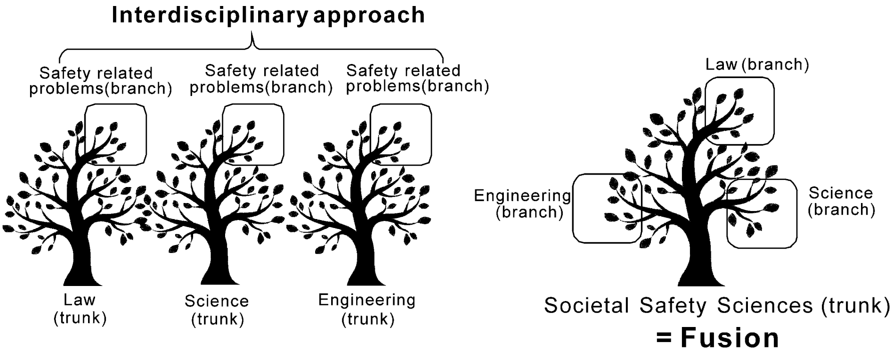

Fig. 1.2 Difference of "interdisciplinary approach" and "fusing fields"
Note: Existing academic fields are not just the three in the figure

there are multiple trees, one for each academic field, with branches of problems related to safety. The researches collect all these branches keeping them at levels of simple additions of the problems.

Our studies form a trunk of societal safety sciences with branches extending to their own fields of study and the branches are fused into the trunk (Fig. 1.2). In the state of fusion, a safety section of the tree trunk shows an organic combination of the existing academic fields. The authors aim to develop into this direction that synthesizes multiple academic fields to give birth to a new academic field of fusion. This book is an experimental publication of our direction.

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Chapter 2
Advancement in Science and Technology and Human Societies

Hiroshi Nishimura, Emiko Kanoshima, and Kazuhiro Kono

Abstract As the phrase civilization of science and technology suggests, modern societies are built on top of highly sophisticated advancement of science and technology. This chapter reviews how societal safety sciences relate to problems in human societies and overviews challenges in modern societies.

Keywords AI · Automobiles · Elevators · Information security · Power generation · Railway · Vulnerability

2.1 Advancement in Science and Technology and Changes in Human Societies

2.1.1 Human History and Transition of Population

This section overviews characteristics and problems of modern societies from the viewpoint of human history. A view over characteristics and problems with a subject, from a level higher than daily viewpoints and metrics, is an imperative preparation for scientific discussions in societal safety. Modern societies have plenty of debates in whether to accept or deny senses of values or technological evaluations; thus, having the habit of taking long-term overviews over discussions with different viewpoints and metrics is worthwhile. This act resembles looking for the Polar Star when lost. The Polar Star does not show which direction to take; however, it is a guide for us to confirm which direction to head into after all.

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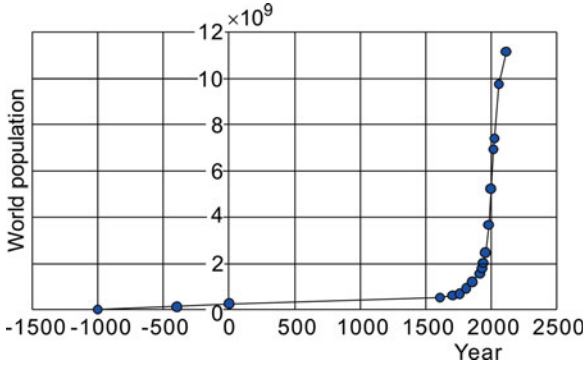

Fig. 2.1 Transition of world population. (Drawn based on the data of UNEP 2011)

In general, growth and decline of population are said to represent the ups and downs of societies. We will start our discussion with the transition of world population (estimate) in Fig. 2.1. The world population with nearly a flat small growth for years, throughout the long human history, shows a rapid increase in recent years.

Despite this rapid rise in population, if we now divide the worldwide food production by our population, the amount exceeds what we need per person. This means, although it is an over simplified calculation, the modern society has secured an ample supply of food and we are enjoying the prosperity. Our population only showed slow increase for a long time until the industrial revolution; thus, modern scientific technology has made large contribution to increasing our food production.

Our current birth rate shows a decrease; however, our longer lives resulted in United Nations' projection announced in June of 2017 that the world population would reach 9.8 billion in 2050 and 11.2 billion in 2100. Science and technology will keep advancing into our future; however, when we recognize that habitable space on earth is limited, we need to feel the higher sense of crisis toward the rapid growth of population.

The key in projecting how the world population will change in the future is how we interpret the transition of shifting into rapid increase. Statistics show that our population showed such transitions twice in the past. The first such point was the eighteenth to nineteenth centuries when the industrial revolution started, and the second point was the 1950s to the 1960s after World War II. The time after the industrial revolution to today is a short period within the long history of mankind. Factors that led to rapid population growths during these years were the energy revolution and power revolution. In the rest of this chapter, we will overview the energy revolution and power revolution in relation to the increase in food production that directly contributed to the rises in population.

2.1.2 Background of Population Increase During Early Stages of Industrial Revolution and Its Historical Meaning

United Nations Department of Economic and Social Affairs showed that the world population at 580 million in 1600 increased to 680 million in 1700 and 790 million in 1750. Once the industrial revolution started, the growth rate rose further, and the world population reached 980 million in 1800, 1.26 billion in 1850, and 1.65 billion in 1900. The rate is clearly different from that up to the sixteenth to seventeenth centuries.

The industrial revolution started in the mid-eighteenth century in the UK. Its driving forces were "inventions of machines" and "invention of steam engine" that used coal for its power source. Especially improvements of spinning machines and Cartwright's power loom powered by a steam engine greatly improved the industrial production centered around the cotton textile industry. The movement required factory workers and large capital. Around the eighteenth century in the UK, Norfolk four-course crop rotation, that allowed agricultural production throughout the year, started to spread over the three-field system and led to tremendous increase in agricultural production. This "agricultural revolution" made population growth possible and secured sufficient labor for the industrial revolution. The nineteenth century saw advancements of heavy industries, like the machine, steel, and coal industries, and new ways of transportation like steam boats and locomotives, to allow mass transportation of material and products.

During the mid-nineteenth century, the industrial revolution spread to other west European countries starting rapid industrializations in Germany and France. The revolution triggered colonialism in the late nineteenth century among the countries that wanted their hands-on cheap material for industrial production and looked for new market development to sell their products. The colonization race among the empires led to World War I in the twentieth century.

2.1.3 Problems We Face in the Modern Society

The world population kept growing into the twentieth century. The count 1.65 billion in 1900 kept rising at a rate of about 0.6% a year to reach 1.86 in 1920. After World War I, the annual rate increased to about 1% pushing the world population to 2.07 billion in 1930 and 2.54 billion in 1950. After World War II, the rate further rose to about 2% a year, and the population exploded to 3.7 billion in 1970 and 5.3 billion in 1990. Later, the rate dropped; however, the population kept growing to exceed 7.0 billion at the end of October 2011 and reached 7.4 billion at the end of May in 2017.

The primary sources of energy and power during the early stages of the industrial revolution were the combinations of coal and steam engines, but they drastically changed after World War II. People developed new energy sources of oil, natural gas, and nuclear material like uranium. The use of methane hydrate is now catching the attention as the energy source for the future. Machines to produce power started with the external combustion-type steam engine, and later human invented the internal combustion-type gasoline and diesel engines. Automobiles with the internal combustion types spread around the world, and the societies developed modern traffic management systems. We then moved on to invent motors in a variety of sizes that use electrical energy. Then the development of technology to distribute electricity led to its application in all aspects of our activities like production and transportation to consumption areas, and productivity, our lifestyles, and convenience were all improved. As a result, the lifestyle in advanced countries turned to the modern style of mass production and mass consumption.

The latter half of the twentieth century, as it is called the green revolution (Hesser 2006), was the time when mass production of grains started. Mexican wheat and Indian rice are well known. As we explained in Sect. 2.1.1, the world is producing food in an amount that far exceeds what are needed for the entire world population. The development of high-yielding varieties largely made possible a big increase in grain production. In addition, securing irrigation water, development of fertilizers and pesticides, and farming machineries to cover huge farming fields all contributed to the increased production. Crop breeding today has even started to reach into the genes. An increase in food production also affected other fields including chemical industries of pesticide, fertilizer, and food additives, civil construction industries of irrigation water management, machine industries of manufacturing farming machineries, and transportation industries of transporting the products.

On the other hand, we are faced with a number of problems we cannot ignore as the negative side of developing new technologies. They are the problems of environmental contamination caused by pesticide and fertilizers, pesticides for long post-harvest transportation, and food additives. These problems are new concerns with food safety fundamentally different from the food problem of famine in the old days. Developing new technologies always involve risks. We are at a stage where we have to rethink how far we want to take the food production technology with these risks.

Mass production and mass consumption result in mass disposition. The world started to recognize the problem of waste around the 1970s together with the other problems of environmental destruction and resource drainage. These problems of the modern societies that affect our environment may lead to concerns with the global environment and harsh weather conditions due to global warming. Nuclear power generation, once expected to be free of drainage in its breeding principle, is no exception. The delay in developing technologies for nuclear waste management and environmental contamination caused by NPP accidents further add to the complication in discussing energy resources.

UN Food and Agriculture Organization (FAO 2017) reports that about 815 million people in the world suffer famine in 2016 (777 million in 2015). The number is less by 132 million than 947 million in 2003; however, 1 out of 9 of the world population is struggling with famine. The modern world is under a complicated situation with "societies suffering malnutrition" and "societies that enjoy excessive supply but suffer health problems from the satiation" that share the same earth and tightly relate to one another. As globalization makes progress, gaps between the rich and poor are spreading over the world. We need to start building global systems to eliminate the gaps of famine and wealth by stepping over the differences in culture, religion, and political systems.

Modern societies are built on top of energy and power from production, transportation, and consumption to waste disposal. For us to make use of resources and energy forever, we need to make fundamental changes to the way of human activities. There is a movement in Europe that claims the need to construct sustainable societies; however, the reality is that only few people recognize the need. We have not yet developed the technologies to make sustainable use of energy and power. To make the changes in our modern societies, we have to first acknowledge that forms of modern production and life are overly dependent on energy and power, and then we need to start active discussions on creating new sustainable styles of life and production.

2.2 Birth of Megacities and High-Speed Mass Transportation

2.2.1 Modern Societies and Megacities

About 10,000 years ago, when human settled and started farming, the communities faced the need for controlling large-scale erosion and flooding. Thus, human formed cities as the hub for politically organizing regions. People that control and use relatively stable supply of storable excessive products lived in the cities. The concentration of people led to large buildings, culture, and civilization and gave authorities to the controllers in the cities. Concentration of people, on the other hand, gives rise to risks of epidemics, fires, and famine. City sizes, thus, had their limits with populations about 100,000 on lands with diameters of 1–2 km. Exceptions like Edo (now Tokyo), during the seventeenth to nineteenth century with a population of about 1 million within a radius of 4–5 km, went through multiple occurrences of fires and epidemics.

The start of the industrial revolution in the late eighteenth century led to development of manufacturing industries, and their productivities made great leaps with cooperation and division of labor among people in the cities. The movement changed cities from controllers of excessive stocks to manufacturing cities. In addition to controlling and consuming excessive farming products, people in the cities started to produce properties and services and consume them. The disadvantages of epidemics and fires caused by concentration of people were then controlled with advancement in medicine and construction of social infrastructures. The development of new ways of transportation eliminated spatial limitations, and outskirts of cities went through rapid expansions, to bring populations of the areas up to 1 to several millions, and in the twentieth century, megacity areas with populations that exceed 10 million emerged.

Functions to control societies in the cities, on one hand, were pushed aside by decentralized market-driven economics; however, on the other hand, the cities still needed central controllers to manage complications from multiple decentralized systems. Cities were the hubs to control regions, and with the advancement of people's economics, they turned into structural elements for people's nations and went through reorganizations.

Jacobs claimed that instead of being built after national economics, city economics grew by taking on functions that national economics could not control. Economic activities grow by innovation, and for healthy growth, corporations within a city have to execute their creations within creative and cooperative networks. National economics expand when a corporation within it innovates a new value. Without it, national economics will decline. Jacobs clearly showed the gradual influence of innovation within a city extending to the surrounding regions and eventually leading to advancement of the national economy (Jacobs 1984). The advancement of global economy is casting light onto this argument through re-recognition of surplus management function and creativity of cities.

2.2.2 Transportation Systems That Support Modern Societies

The transportation system is one of the social infrastructures in modern society that takes for granted ways for repeatedly and regularly transporting people, products, and information in massive quantities. Railways and steam boats were the main players in the nineteenth century, and in the twentieth century, automobiles expanded the range of people's daily livings and airplanes made the world narrower. Especially railways and automobiles made great changes to cities.

The railway was born in the nineteenth century as steam railways to connect cities. Within cities in Europe and the USA, horsecars debuted in the early nineteenth century which were taken over by electrically powered trams later in the same century. Cities, where people used to travel on foot, showed gradual increase in their spatial spread. Geographical spread of cities led to further concentration of economic activities and then even bigger expansion of city coverages. People who disliked city-specific problems that came with concentration of people moved out along railways extended to the outskirts and started to commute on railway networks. City areas then radially grew to radii over 10 km adding further complication to their problems of large-scale and dense population. Howard, in his theory of garden cities, suggested to link midsized cities with railways to resolve problems with overpopulated large cities (Howard 1902). The movement, however, whether intended or implemented without plans, led to giving birth to megacities with radii of tens of kilometers.

People started to buy automobiles after Ford's Model T debuted in 1908. Narrow roads and public transportation already in existence delayed their acceptance to city areas; however, the people and economics of cities were attracted to them, and every city started to construct road networks and build parking areas. The constructions, however, could not catch up with the rapid growth of the number of automobiles. People, with their automobiles, started to move to suburbs without railway service. Spatial expansion of cities overloaded road facilities. Developing low-population cities to lessen the load on roads made city areas grow even wider. The cities that used to grow radially then kept growing like galaxies into sizes that even exceeded radii of hundred of kilometers. When cities expand, the original attraction of them is lost. Today, we can probably say that there is no city free of problems related to automobile transportation.

Modern megacities are supported by two types of transportation systems: the railways and automobiles. There is another means of transportation always in place within megacities, and that is the elevator. Without elevators, skyscraper buildings cannot be built. Le Corbusier (1933) was the first to discuss the importance of them in his book "La Ville Radieuse (The Radiant City)," also known as "The Vertical Garden City." The reality of modern megacities with large numbers of skyscrapers built in random manners is not what he idealized; nevertheless, elevators are indispensable for them.

2.2.3 Disasters and Vulnerability of Megacities

Concentrated population is one of the attractive features of a city; however, it is also a factor of expanding the magnitude of damage in case of natural and social disasters. There have been a great number of cases where cities were attacked by large fires or serious epidemics as well as many cases of large city damages caused by natural disasters. The case of disaster in Pompeii in ancient Rome is well known, but more recently, for example, the 1755 Lisbon earthquake devastated the city of Lisbon and is said to be a factor for the decline of the Kingdom of Portugal. Rousseau, who lived in the same time, claimed that the damages would had been smaller if people were more scattered with less property. He emphasized the man-made disaster aspect of earthquake damages pointing to the large condensed population and people, to protect their properties, not fleeing (Rousseau 1756). There are plenty of other cases of natural disaster attacks on cities, and every time, people suffered great damages. These cases put us into deep contemplation about whether concentrating people to cities is really desirable.

There are many of conditions for establishing cities in the modern society. Means of transportation like railways, roads, and elevators are such conditions together with other indispensable infrastructure of information communication, electricity, gas, and water supplies. Also, cities have various structures including underground shopping centers, skyscrapers, and developed coastal areas. When such structures suffer large damages, not only the city functions are interrupted, but a great number of lives and properties are lost; in other words, cities have natural vulnerabilities. Vulnerabilities of cities are evident with larger size cities. In fact, when we compare the 1995 Great Hanshin-Awaji earthquake with a death toll of over 6000 and the 2016 Kumamoto earthquake that took 267 lives in Japan, the level of damages was quite different even though the earthquake sizes were about the same.

Damages from disasters on cities depend not only on the level of concentration but also on their quality. One lesson from the Great Hanshin-Awaji earthquake was the damage grew largely due to concentration of wood-made houses that did not meet today's Building Standards Act in Japan. Natural disasters do not target areas with high population concentration. If we are to give up concentration by abandoning cities, we have to think about the values of what we will be losing. There are many lessons to learn from past experience of disasters, and some of the countermeasures are possible only in cities.

People have worked on controlling erosion and flooding and have built seawalls and breakwater. They were efforts to build robust cities against disasters. For cases that such systems and structures cannot prevent damage, we have prepared evacuation facilities and built systems for cooperation among civil organizations to counter disasters. If we continue to accept benefits from concentrating in cities, we have to think how to, at the same time, develop multifaceted systems of disaster prevention, mitigation, and reduction. The preparations by New York against hurricane Sandy, after learning from hurricane Katrina, were a success case. We have to avoid excessive concentration and monocentric concentration; however, if we acknowledge the vulnerabilities and take necessary measures, we can continue to enjoy the benefits of concentration to cities.

2.3 ICT, AI, and the Modern Society

2.3.1 Development of ICT and Highly Advanced Information Society

The history of modern industries consists of the time of farming up to the early eighteenth century, the time of manufacturing from the mid-eighteenth century to the twentieth century, and the time of information and knowledge in the twenty-first century. The world is making great changes from societies that valued farming and manufactured products to information societies that place importance in information and knowledge formed from them.

In the modern information society, where an enormous amount of information is generated, stored, and processed daily, information is generally processed at high speed by the computer and transferred to a wide audience via a variety of communication methods. Information and Communication Technology (ICT) that supports the information society showed rapid advancement in the 40 years starting in 1980. The personal computer first introduced in 1974 spread throughout the societies in the

1980s and the 1990s. The spread of personal computers led to digitalization of information enabling not only mass reproduction of information but also greatly enhanced accuracy, efficiency, and reliability of information processing and communication. During the mid-1990s to the 2000s, the Internet spread around the world explosively, and broad-band communication was made available allowing large volume communication at high speed. The high-speed Internet realized access to enormous quantities of multimedia contents at anytime from anywhere in the world, and in addition, everyone has the hands-on ways for broadcasting of information; that is, communication without limitations of time and space has been made available. As information systems and the Internet were shaped as one of the societal infrastructures, such functions as electronic trading or electronic government turned available, and economics, society, and government are all heading toward efficiency. Technologies for safety and security systems are also on the rise, e.g., keeping eyes on children with monitoring cameras and global positioning systems (GPS).

As computers turned smaller and faster like smartphones as well as the recording media, cloud computing popped up, and ICT is now accessible anywhere. The advancement into the time of ubiquitous network enabled anyone to access information at anytime from anywhere and any device and now into the era of Internet of Things (IoT) where a variety of things themselves hook up to the Internet to exchange information for automatic recognition, measurement, and control. How to make use of information and technologies is important in the advanced information societies. New attempts that apply state-of-the-art technologies like artificial intelligence to analyze big data are being tested, e.g., a new financial service "Fintech."

2.3.2 *Information Security in the Information Society*

As the societies are rapidly advancing into the information age, "digital divide" is now a social problem, which is the inequality among individuals in their abilities to make use of information and their communication environment. The advanced information society is also facing new problems including a variety of cybercrimes that misuse computers and networks, net troubles of careless slandering and bad-mouthing of others on the Internet, copyright infringement from reproducing digital information, and health problems from excessive dependence on Internet or smartphones.

In general, information security means to keep information in its complete form, so only the proper user with access rights can use it at any time. Events that threaten information security or that are highly likely to do so are called "information security incidents." Information security incidents are caused by cyberattacks; unauthorized access; transfer of malware; intended acts by malicious people, and further in addition by unintended acts due to operation errors or carelessness; and even natural disasters or malfunctions.

Today, a large number of cyberattacks are around with knowledge of human abilities and typical behavior for the purpose of stealing confidential information or money. An example is password list attack (list-based attack) that is one form of password cracking and is frequently reported. The attackers know people tend to use the same password because they have limits to how many they can memorize. A targeted threat or an advanced persistent threat pretends to be a customer and sends malware to members of target organizations. It is one of the cleverest ways of deceiving people among the number of cyberattacks. The amount of damage from illegal remittance via Internet banking amounted to over 30 billion yen in 2015 in Japan. Organized crimes of unintended withdrawal using fake cards do not fade out. Individuals and corporations suffer since 2015 from ransomware sent to users with programs that lock up computers or encode files and demand ransom to unlock the access.

We need countermeasures from technical, physical, organizational, and personal aspects to protect information assets from these threats. Over 80% of information leakage in Japan are caused by human errors. Protecting information assets in the advanced information society requires raising the information literacy of the users. The administration and corporations have to protect huge amounts of information compared to those of individuals, and thus they have to take proper measures against risks in relation to their possibilities and intensities. Furthermore, any countermeasure can be cracked sometime, and the idea of "defense in depth" that we protect information assets by taking multiple measures in multiple layers is important. We need to take these countermeasures at the entrance and exit points of a network and at each point within the network.

2.3.3 AI and Safety and Security in Human Society

One of the technologies that is making advances in an astonishing speed is artificial intelligence (AI). The 2010s saw a number of AI topics that caught the attention of the public, e.g., AI, at times, beat active professional Go (strategy board game) and Shogi (Japanese chess) players, or a novel written by AI passed the first round judging of a literary contest.

According to the 2016 white paper on information and communications in Japan (MIC 2016) up to the 1990s, AI mostly consisted of software that made guesses by searching simple rule bases or knowledge-based systems that stored various information in searchable formats; they were way far from computers that "behave almost like human." In the 2000s, the technology of machine learning was developed that once people teach features to identify and distinguish data, computers could then on learn rules and knowledge to categorize data without human intervention. In the 2010s, deep learning with models that resemble human neural network was developed. Deep learning extracts features from sample data; thus, AI itself understands and expresses the data concept (meaning), i.e., it executes information processing, that humans unconsciously perform within their brains, to certain extents.

AI is applied not only to information systems like search engines on the Internet but also to speech recognition and synthesis or voice-activated search systems with smartphones, and it is making changes to our daily lives. AI technology is making its way into appliances around us like robots that effectively clean the floor based on sensor data or convection microwave ovens that learn the user's preference. Fintech we touched about in Sect. 2.3.1 cannot perform its financial services without AI. There is no doubt that AI will continue to make large influences in various industries. It is said that AI will put automatically driven automobiles on the roads in 2020. Expectations are high for AI to contribute to improvements in convenience and safety of our societies by diagnosing illnesses and suggesting treatment plans in the medical field, building individual personality-based study plans for students in the education industry, crime prevention by detecting abnormality with surveillance cameras in the security industry, and application to decision-making support for disaster prevention.

Oxford researchers C. B. Frey and M. A. Osborne predicted (Frey and Osborne 2017) that with AI making its way deep into our societies, among the over 700 types of occupations in the USA, about 47% are likely to be replaced with AI or robots within the next 10–20 years. As people and AI start to head into their separate directions, people's work will be more creative leading to possible economic problems. We will have to start making multifaceted discussions about various problems that we can see coming in the future. They involve humans' sense of ethics and values being affected by AI judgments, responsibilities about accidents caused by AI judgments, legal issues related to using and protecting personal information and privacy, concerns about education to bring out creativity through learning the advantages and limitations of AI technologies, qualification of researchers in AI research and development, and many other problems that lie ahead of us (CAO 2017).

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Chapter 3
Contemporary Societies and Risk

Shoji Tsuchida, Seiji Kondo, and Kenji Koshiyama

Abstract We plan our safety measures under economic, personnel and time constraints. The extent of how far we take these measures depends on our acknowledgement of risk of whether we "stop because it is risky" or we "cannot stop because of its benefits despite its risks". This chapter discusses our risk recognition and concerns about mass media that strongly affect our risk recognition. It also overviews differences in risk evaluation about natural disasters and social disasters.

Keywords Disaster frequency · Mass media · Risk assessment · Risk recognition · Vulnerability approach

3.1 How People Cope with Risks in Contemporary Societies

3.1.1 Risk Perception by Human

Advancement of scientific technologies has given a great number of convenience and benefits to human. The power, however, that scientific technologies produce is far greater than what we, a mere biological being, are born with. We thus started to have anxiety against risks associated with scientific technologies going out of our control. In fact, the 2010 Gulf of Mexico oil spill and the 2011 Tokyo Electric Power Company's Fukushima Daiichi NPP accident, although such events are rare, had us experience the great dangers and damages that accompany the introduction of scientific technologies. ISO defined risk as "effect of uncertainty" (ISO 2009). Risk perception is about acknowledging future dangers with uncertainty in whether they will actually take place or not and, at the same time, acknowledging future benefits with uncertainty in whether they can be gained or not.

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Humans are not good at making probability-based judgements of uncertain events. And we tend not to carry conflicting emotions about an event at the same time; thus, if we try to perceive the negative side of an event (danger) and its positive side (benefit), we get exhausted. We, therefore, tend to fall into the pitfall of perceiving risk based on partial information about an event, unless we have high motivations to evaluate the event. We also lean towards single-sided judgements that there are no benefits with dangerous matters or no dangers with profitable ones by ignoring one or the other, i.e. danger or benefit. This tendency is called affect heuristic because it is an emotional judgement of "bad things (matters disliked) are dangerous" or "good things (favored matters) are profitable" (Finucane et al. 2000; Tsuchida 2011). Also, not limited to risk perception, we have the habit of only looking at information that support our judgements (self-justification). We carry our own ideas (schema) about the reality, and we tend to perform risk perception based on our own ideas.

Another bias in making a judgement is that it is affected more by information that is easier to remember. Tversky and Kahneman reported results of an experiment where Americans were asked if more English words starts with "r" or have "r" as the third character, and although there are more of the latter, most Americans answered that there are more that start with "r". The reason was because the former is easier to recall compared to the latter (Tversky and Kahneman 1974). Similarly, those with strong memories of airplane accidents, tend to think there are more airplane accidents than automobile accidents.

When we make judgements about risk, "dread risk" and "unknown risk" are clearly the especially dominant factors. We tend to judge matters that are more frightening and matters that we lack knowledge about as more dangerous (Dimension of risk perception: Slovic 1987). People basically have a logical and conscientious judging system (fast thinking) and an intuitive and emotional judging system (slow thinking) (Kahneman 2011). Risk perception relates to emotions of fear, anxiety and desire; thus, it receives strong effects from the intuitive and emotional judging system. This tendency is one of the reasons for our risk perception to differ from objective facts. There are about 126 psychological models and theories, in addition to the one discussed above, that cause distortion in our risk perception.

3.1.2 Significance of Risk Perception for Resolving Social Problems

We want to live in societies that offer more safety; however, when we implement safety measures to resolve social problems, we have restrictions in budget (economic restrictions) and human resources (personnel restrictions) and when to complete the work (time restrictions). The more budget, personnel and time we spend, the level of safety goes higher; however, we end up spending the best within reasonable and rational ranges. This is called the “as low as reasonably achievable (ALARA)” standards. Our risk perception, at the end, determines the levels of “reasonable and rational ranges that are possible”. In other words, the extent to implement safety so it is “safe enough” depends on our risk perception of whether we “stop because it is risky” or we “cannot stop because of its benefits despite its risks”.

A measure to reduce the danger of an event often increases the odds for another risk in realistic safety measures, like not using preservatives which are food additives will increase the danger of food poisoning. Also, a strategy to lower risks often results in reducing the benefit, e.g. driving slower delays the time of arrival at the destination. The final decision to prioritize which risk to lower among all dangerous events or how far to reduce the risk when the cost has to be balanced with profit depends on our risk perception.

Our risk perception is affected by the situation that surrounds us. For example, developing countries with large crop damage by locusts could face starvation to deaths in the following year. Under such circumstances, if it can effectively control the outbreak of insect pest, the carcinogenicity of pesticide is often unrecognized. In general, under poverty conditions, people develop strong feelings to make profit and tend to recognize present dangers as within safety limits. In contrary, when surrounded by wealth, people do not have an urge to make profit and recognize even the smallest danger as unacceptable.

There are two styles of risk governance in securing safety for the society; one is top-down and the other is bottom-up style. The top-down style typically has skilled administrators, researchers and engineers to plan and implement safety measures by giving instructions or orders to the general public. On the other hand, in a matured democratic society where democracy has penetrated the society with a large number of citizens armed with advanced education, the people want to build their own safety measures. This style is bottom-up. If the general public in the bottom-up style forms risk perception that match those of experts, i.e. researchers, engineers and administrators, the results are the same safety measured with top-down style.

Slovic, however, pointed out that risk perception between experts and the general public is largely different (Slovic 1987). For example, experts recognize that automobiles carry higher danger than NPPs based on death toll data; however, the general public tends to recognize that NPPs are more dangerous. These differences in risk recognition often lead to the general public refusing the safety measures suggested by experts in bottom-up type policies. For bottom-up-type policies to function reasonably, therefore, risk governance or risk communication plays important roles in balancing risk perception for the whole society.

3.1.3 Contemporary Societies and Mass Media

In the contemporary world, the mass media largely affects risk recognition by the people.

One of the phrases that describes today's societies is "advanced information society". The advancement of information communication technologies allows us to transfer various information over the world in split seconds. We can now easily place our hand on the information we want anytime and from anywhere using these technologies.

The information generator takes a variety of forms including the central or local government, a corporation, a non-profit organization (NPO), a school, a hospital or local residents, but among them all, those that carry information broadcasting as their occupation and send out information towards the mass are the mass media. Many of them take an enormous amount of information, edit and process them into their own shapes (Tuchman 1978) and constantly and continually send them to the audience and readers via the television, radio, newspaper and magazines. These conventional style media are called legacy media which are losing chances of reaching the youth after the internet made its way to the world. Nevertheless, they, in fact, still have large influences.

The mass media carry with them the "agenda setting function" to select what to discuss at the time and present them, the "gatekeeping function" to guide the mass to look at specific topics and the "watchdog function" to keep eyes on actions by power organizations like policy decisions by the government, executions by the administration or judgements by the judicial system. The mass media, however, tends to shape public opinions along the lines of the mass interest, thus, often end up causing social confusion themselves. Especially when a large number of reporters gather at the scene of disasters or accidents, they tend to corner and torture the victims. These problems of mobs of overheated reporters are sometimes called "media scrum" in Japan extending the meaning of the original English phrase to such happenings. It has also been pointed out some years ago that the media after "sensationalism" often focus on the pain and grief of victims and produce exaggerated information at the price of exposing privacies (Virilio 2005).

Information transfer by the mass media, if conducted effectively, can lead to swift actions against approaching dangers, or it can also cause amplification of initially minor troubles leading to serious situations. In *Risikogesellschaft* (Risk Society), Beck pointed out that where risk has spread to individuals and societies, the role of the mass media cannot be ignored (Beck 1986).

Events with social impact like disasters or incidents turn into "social events" only after they are publicized by the media. For example, when victims of a major earthquake living in temporary housing die one after another with earthquake-related deaths, if the media does not cover the happenings to transfer and share the information with those that did not suffer from the disaster, the serious events are the "same as never happened", and there will not even be the desire to learn lessons from them. In contrast, composing a "media event (Dayan and Katz 1992)" in a way so we can learn lessons can expect more supporters and thorough preparations throughout the nation even in case of local disasters. The risk society and the information society develop in an interrelated manner. Risk is heard of as information, and the relay of information always has some risk. We need to acknowledge these facts to survive through the contemporary society.

3.2 Evaluation and Measures Against Risks in Contemporary Societies

3.2.1 Purpose of Risk Evaluation

Whether the disaster is natural or social, the concept of risk covers a wide range and there are a number of evaluation methods about it. For example, the effect of chemical substances to the human body or cancer risk on health with food items are evaluated with dose-response relationships that relate the biological reaction to dosage of chemical substances to set the guidelines for standards of making judgement. New disaster preparations are often discussed with the damage volume (cost of damage) and probability of damage causing disaster (exceedance probability). Other practices include setting standards for part strength from the relation of damage (destruction) to strength and frequency of force applied on the part or developing insurance plans based on the relation of magnitude of damage from an accident and the frequency of the accident.

All these evaluation methods share the same purpose of setting quantitative guidelines (1) against an event that is likely to happen, (2) to implement some countermeasure, (3) so proper comparison and judgement are made. Risk evaluation is nothing but a probabilistic (quantitative) description of a damaging event that is likely to happen in the future for the purpose of making a judgement. At each point in history, human society has recognized actual risk through risk evaluation and executed measures to reduce the risks. The safety of our society now is the accumulated result of such efforts.

3.2.2 Understanding Disasters

A natural disaster is "a damaging event caused by natural phenomena", meaning just a natural phenomenon alone does not mean a disaster. Today's social sciences have a mainstream concept about the relation between natural disasters and human society that "natural disasters are caused by the combination of external force from the nature and vulnerability of the society" (Wisener 2003). Thus, in expressing natural disasters as risks, the expression is

$$[\text{risk}] = [\text{hazard}] \times [\text{vulnerability}]$$

where [hazard] means a natural phenomenon and [vulnerability] the social environment. If we apply this formula to general risk evaluation, it means

$$[\text{probability of a natural phenomenon over a set strength}] \\ \times [\text{amount of damage due to social vulnerability}]$$

and it is unique in combining natural and social phenomena. This expression shows us that a same size hazard would result in different magnitudes of damage depending on where it happened, and a hazard with physical size of twice as big does not necessarily mean the amount of damage is also twice. Damage from a natural disaster is not only dependent on the magnitude of the natural phenomenon, but it also depends on strengths in prevention and response to it at each region that is hit and also on the interrelated effect of the natural and social phenomena.

A social disaster is "a man caused disaster that causes damage to people and the society", and we may want to formulate it similarly to a natural disaster with the cause being the [hazard] and people and the society that suffers damage the [vulnerability]. Today, however, such a formulation is not common in evaluating risks of social disasters.

In the contemporary society, natural phenomena change slowly; however, human life and social environment change so rapidly. For both natural and social disasters, human- and society-side factors have stronger effects on risk evaluation.

3.2.3 Difference in Evaluations of Natural and Social Disaster Risks

The most common risk evaluation takes the form

$$[\text{amount of damage caused by the event}] \times [\text{probability of event}]$$

As we discussed earlier, clear distinction of natural disasters and social disasters is difficult; however, this section will discuss the differences between the two.

In general, in the contemporary society, natural disasters are less frequent than social disasters. Their low frequencies make it difficult to predict occurrences of natural disasters in a timeframe. Damages that local areas suffer from natural disasters are diverse; thus, estimating the amount of damage to local communities is extremely difficult as well. Evaluating risk from natural disasters, therefore, takes the form of assuming several scenarios that can take place and estimating the amount of damage for each scenario instead of carrying out strict calculations. Summing up [magnitude of damage × probability of occurrence] for all expectable cases gives the expectation of damage that serves as the basic evaluation metrics for discussing measures and their extent.

Natural disasters also have different effects depending on the regions. Sociology of disaster offers ways to clarify which societies are vulnerable to what disasters and how such vulnerability is born. This method allows relative comparison of how susceptible each region is against a disaster, and it gives the guideline for regional risk evaluation against natural disasters. Kenneth Hewitt, on the other hand, warns against determining risks of natural disasters only by reviewing social vulnerabilities and ignoring external forces of the nature. He claims natural phenomena are hazards that cause damages; thus, their attributes should affect risk evaluation (Hewitt 1997). Estimating levels of damage is not easy; however, natural phenomena and geological features are analysable with physics, and the results can be probabilistically expressed. The National Seismic Hazard Maps for Japan (HERP 2005) is one such example that gives the guideline for risk evaluation of natural disasters with relative assessment for each region based on probabilities of occurrences of natural phenomena, the risk factors. Both reports are useful in promoting preparations against them at local regions.

Most risk evaluations of social disasters are limited to events with relatively simple relations between cause and effect (damage). Data on frequencies of such events are readily available, thus, statistical analyses are feasible with high accuracy. Limiting the events also make ways for experiments and observation-based analyses. These evaluations are much more accurate than risk evaluations of natural disasters. On the other hand, among social disasters, those with low frequencies like wars to global pandemic apply methods similar to risk evaluation of natural disasters.

As scientific technology advances, phenomena are better clarified, and analysis methods are enhanced and significances of risk evaluation for both types of disasters are higher. At this point, however, from cause and effect relations, risk evaluations of social disasters tend to lead to direct and actual measures and preparations. Since the two risk evaluations differ in their purposes and accuracies, comparing the two by putting them on the same table is not advisable. We must understand the meaning of the quantitative evaluations from the methods and their purposes.

3.2.4 Discussion on Global Risk

Among the globally discussed risks in the contemporary societies, those counted as significant, with the magnitudes of effect and possibilities of occurrence, are "extreme weather events", "natural disasters", "large-scale involuntary migration", "terrorist attacks", "cyberattacks" and "failure of climate-change mitigation and adaptation" (World Economic Forum 2017). If we look at specific regions, the possibilities of occurrence drop; however, for the entire world, the odds are high, and they will affect the entire world. These risks were identified as combined wisdom by specialists and experts and although, not quantitative, we can acknowledge them as our primary global risks.

For each of these risks, quantitative risk evaluation is in progress for purpose, e.g. commodities are available in insurance and investment industries. Concerns on extreme weather events and natural disasters led the United Nations to form frameworks, agreements and organizations for them, and these topics are now discussion items among the world countries. Risk evaluations are discussed there based on legitimate data to set target standards for each country.

As technology advances, people, capital and information travel beyond borders of countries raising potential risks within our societies. We now need to form cooperative systems to take measures against them. For our cooperative efforts of risk recognition and risk mitigation, the common language of "risk-related mathematics" is playing a big role.

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Chapter 4
Modern Societies and Establishment of Scholarship

Toshihiro Kawaguchi and Tadahiro Motoyoshi

Abstract The previous chapter discussed characteristics of contemporary societies in problems related to safety. Histories of birth of societies and cities and their maturing are deeply related to histories of birth and development of scholarship and science. This chapter overviews how scholarship and science were born, how they branched out and specialized, and then how they unified and formed interdisciplinary studies beyond boundaries of specialized fields. It also explains histories of various academic fields related to societal safety sciences.

Keywords Industrial revolution · Safety engineering · Scholarship · Scientific revolution

4.1 Human Societies and the Start of Scholarship

4.1.1 Origin of Scholarship

Oxford Advanced Learner's Dictionary defines the scholarship to mean "the serious study of an academic subject and the knowledge and methods involved." Subjects that we study at universities, philosophy, psychology, law, economics, sociology, science, engineering, and medicine are all scholarships systematized based on knowledge and theories. Here we will first review the origin of scholarships.

Human, since ancient times before civilization, empirically found regularities in the nature deeply related to their lives, i.e., movements of the sun and stars, transition of seasons, and change of weather. We then acquired knowledge about these natural phenomena and applied them to farming of crops and livestock. The ancient Mesopotamian civilization, said to had started around 3500 BC, had a number of city states. Priests and leaders that ruled the city states defined letters, numbering

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systems, weights and other measures, the calendar, and so on and acquired various knowledge about mathematics and astronomy. The ancient Egyptian civilization, said to had started around 3000 BC, carried the knowledge from Mesopotamia and established the basics of mathematics and astronomy.

During the time of Mesopotamian and Egyptian civilizations, people built canals and irrigation facilities for improving their farming work, and also huge structures like pyramids as city states formed. These works added knowledge about land survey and astronomy lifting people's understanding of the nature to much higher levels. People at the time, however, believed gods made nature's moves that gave people benefits and, however, at times would pose threats to the people. In other words, people were dominated by the nature leaving their destinies in the gods' hands. The understanding of nature at this time was merely an accumulation of empirical knowledge that was necessary for autocracy that led people's livings. Thus, there probably was no attempt to explain nature systematically in a scholarship manner.

When poleis were established in ancient Greece around 800 BC, efforts to establish a systematic explanation of the accumulated empirical knowledge about the nature with unified principles started. This move is understood as the origin of scholarship that attempted to explain the world by systematically understanding the nature with laws and theories within a civilization that explained all phenomena as god's act.

Thales (~625 BC–~547 BC) is said to be the first philosopher that put scholarship into practice. Thales and other natural scholars of Ionia searched for "arche (principle)" that formed the origin of nature and all things. Thales believed water was the arche constructing everything in the world and preached that everything was a transformation of water. Ancient Greek philosophy started by Thales was carried over to Plato's (427 BC – 347 BC) idealism (theory of "ideas"), and the basis of scholarship was established. Idealism asserts that reality is constructed upon idea and individual reality that we sense is merely provisional images. Plato attempted to understand the world of reality in a top-down manner and theoretically systematized it with ideas.

The concepts of natural scholars starting from Thales were summarized by Plato's student Aristotle (384 BC – 322 BC). Aristotle was critical against the concept of placing formless ideas in the center and started to preach the concepts of "eidos (form)" and "hulê (matter)." Eidos are existing substances that are observable in the real world and hulê material or ingredients that form substances. For example, for a wooden table, its eidos is the shape of the table and hulê is wood. Describing substances under observation with distinction between eidos and hulê is the basics of scientific observation. Aristotle built the basic scientific theory and methodology of describing the results of observing substances, storing the results, organizing and systematizing them. He further divided scholarship into specialized fields depending on the substance. These fields were physics, astronomy, meteorology, politics, ethics, and so on, and Aristotle systematized each field. Understanding nature in this manner largely contributed to raising people's interest into scholarship. And categorizing the nature, setting the divided nature substances as objects for fields, and understanding the world in a bottom-up manner are the first of scientific thinking, and his work is said to be the origin of the variety of scholarships.

4.1.2 Decline of Scholarship in the West and Its Development in the Arabic Regions

The number of scholarships originating from Aristotle of ancient Greek continued to develop into the first century AD. Then, however, scholarship in Europe declined until the Middle Ages. Techniques in civil engineering and practical solutions for supplying water and building roads advanced; however, scholarships as science did not record much progresses.

Among the causes of the decline of scholarships in European societies during this period, one was that development of physics in Greek came from the desire to "understand the structure of the world." Europe back then was dominated by the Christian churches which taught that God was the only being that clarified the truth. Scientific scholarships that tried to explain various phenomena based on theories conflicted with Christian theology, thus, were frowned upon and declined.

Modern European historians look back at the time after ancient Greek to the Middle Ages as the "dark ages" of the world's scientific development. Recent researches, however, revealed that Islamic civilization advanced in Arabic countries during the ninth to the fifteenth centuries (Jacquart 2005). During the era in Arabia, references by Hippocrates (460 BC–375 BC), Plato, Aristotle, and so on were translated into Arabic leading to development of Arabic science in astrology, mathematics, and medicine. During the time of Abbasid Caliphate (750–1258), an intellectual center "House of Wisdom (Bayt al-Ḥikma)" built in the capitol Baghdad gathered scholars of all fields and all ethnic groups of Turkish, Iranian, and Jewish. It is not an exaggeration to say that Arabic science was ahead of European science from the eighth to the eleventh century (Haskins 1927). The Arabs took over the Christianity-dominated Europeans to lead the world of scholarships.

4.1.3 Birth of Universities and the Twelfth-Century Renaissance

In the twelfth century in Europe, movements started to reevaluate the heritages of ancient Greek civilization and revive them. The ancient Greek scholarships not passed on within Europe were transferred to Arabia to go under further development and were reimported back to Europe and translated from Arabic to Latin. The restoration of scholarships in Europe then that started by accepting Arabic sciences is called the twenty-first-century Renaissance (Haskins 1927).

Table 4.1 Primary universities and their years established

Year established	Name (Country)
1088	Università di Bologna (Italy)
1150	Université de Paris (France)
1167	University of Oxford (England)
1173	Università degli Studi di Salerno (Italy)
1204	Università a Vicenza (Italy)
1208	Universitat de València (Spain)
1209	University of Cambridge (England)
1215	Università di Arezzo (Italy)
1220	Université d'Orléans (France)
1222	Università degli Studi di Padova (Italy)

Data source: Haskins (1923) and latest data

During that time, a number of universities were born in the cities of Europe (Table 4.1) where translations of Arabic science into Latin took place. Universities at that time had the task of studying the vast amount of knowledge from the ancient Greek sciences and spread them throughout Europe (Haskins 1927). During this time, books on medicine by Hippocrates and publications by Aristotle were translated into Latin to merge into systematic teachings with those of Christianity. Philosophy based on Aristotle's work was called "scholastic philosophy" and turned into major scholarships at universities in Europe. The rise of Greek scientific rationality, however, led to heated discussions with Christian beliefs. Aristotle's descriptions of the world conflicted with the teachings of Christianity and European scholars argued over where the truths were (Haskins 1927).

After the twelfth century was over, the Faculty of Arts at the University of Paris took the central role in promoting "Latin Averroism" that supported teachings by the Arabic philosopher Averroes (Haskins 1927). Averroism taught a double-truth theory that despite the discrepancies, both Aristotle's philosophical truth and truth of the Christian teaching were both acceptable. The churches and orthodox theologians strongly opposed Averroism and often condemned it heretical. In 1277, the bishop of Paris, Étienne Tempier (? – 1279), researched the debates at the University of Paris and declared that anyone in support of the 219 Averroism propositions will be condemned and kicked out. In Europe, where visions of the world that casted doubt on Christianity were unacceptable and while accepting Aristotelianism, its cosmology and theory of motion were not accepted.

4.2 Birth of Modern Science

4.2.1 Pioneers of Modern Science

In the European societies back then, people believed in Ptolemaic geocentric cosmology that placed the earth at the center of the universe. Nicolaus Copernicus

(1473–1543) discovered that his theory that set the sun at the center of the universe explained planetary motions rationally and beautifully. This Copernican theory was often quoted in scientific discoveries that conflicted with the Christian belief. Copernicus, however, had a Christian church title and is said not to have explained Copernican theory in a way that opposed Christian teachings (Butterfield 1957).

Astronomer Tycho Brahe (1546–1601) kept accurate records of celestial observations. Johannes Kepler (1571–1630) discovered that planets circled around the sun in elliptical orbits with the sun being one of the foci and that the line segment connecting a planet and the sun swept regions with constant areas during a set time period. In his publication *Astronomia nova* (New Astronomy), he wrote about what are known today as Kepler's first and second laws of planetary motion. At about the same time, Galileo Galilei (1564–1642) discovered the "law of falling bodies" that the time for a body to fall freely was independent of its mass and was proportional to the square of the elapsed time.

In the seventeenth century, scientific approaches to the huge amount of data, collected through celestial observations and physical experiments, started to look for essential relations in natural phenomena trying to construct unified theories and axioms. René Descartes (1596–1650) discovered the law of inertia that a body in motion continued to move, unless there was resistance, without applying force to it and opened the world of objective mechanical theories governed by mechanical forces. Kepler, Galilei, and Descartes are said to be the scientists that built the basics of modern science.

Both Kepler and Galilei, however, believed that God was a great mathematician and the nature God created was written in mathematical words. Their pursuit of nature was in line with their beliefs in Christianity, and they were trying to understand God's will. Science today has a variety of aspects including human ruling of parts of nature, experiments, discovery of laws, mathematical physics, and mechanical views of the world. Each of these elements had profound relationships with Christian beliefs in Europe when it was born at the dawn of modern science (Haskins 1927).

Isaac Newton (1642–1727) from England gathered the results of Copernicus's "Copernican theory," Kepler's "laws of planetary motions," and Descartes's "law of inertia" and synthesized them into a theoretical system to form the basics of modern science. Newton, in his 1687 publication of *Philosophiæ Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy), mathematically proved planetary motions and explained the "law of universal gravitation," "law of inertia," and other results. His work proved that bodies and celestial motions are mathematically explained in a unified framework. By the end of the seventeenth century, a highly generic system of theories was established instead of a collection of fragments of knowledge. An English historian Herbert Butterfield calls this era of revolutionary changes in natural science that gave birth to modern science, "the seventeenth century scientific revolution (Butterfield 1957)."

4.2.2 Birth of Academic Societies and Specialized Fields

Among the contributors to modern sciences, some had teaching jobs at universities. Galilei taught mathematics and astronomy at University of Pisa and University of Padova. Newton held the position of Lucasian Professor of Mathematics at the University of Cambridge. In the seventeenth century, the scientists established new communities, academic societies outside of universities. The wealthy class in control of politics, economy, and culture in cities competed with churches at the time and sponsored their formation and operations. "Accademia dei Lincei (Academy of the Lynx-Eyed)" founded in 1603 in Rome for the pursuit of nature is said to be one of the oldest of such societies (Furukawa 2000). In Firenze (Florence), Italy, the House of Medici sponsored the "Accademia del Cimento (Academy of Experiment)," and many scholars conducted a variety of experiments as the academy name suggests. In 1662, the King of England, Scotland, and Ireland, Charles II (1630–1685), gave Royal Charter to the Royal Society of London, started in 1660, that functioned as the hub for scholars dedicated to new scholarships for studying the nature. In 1665, the society started periodic publication of *Philosophical Transactions* so the members could publish their research results. It was the beginning of the system of academic journals for scholars to publish their accomplishments in scientific researches.

The establishment of Royal Society of London was largely affected by Francis Bacon's (1561–1626) scientific ideology that science ruled the nature. Bacon, known for his quote "For also knowledge itself is power," believed that nature given to human by God could also be ruled with the power of knowledge. The Royal Society of London was established as a community for researchers of the nature that strived to understand many natural phenomena through observations and experiments. In 1666, "Académie des sciences (Academy of Sciences)" was established in Paris which was nationally supported, instead of by churches or private patrons, to carry out scientific researches under the support by the nation (Ornstein 1928).

The spirit of modern sciences established by Bacon, Descartes, Newton, and so on inspired French philosophers in the eighteenth century, and they believed the scientific revolution would not only advance natural research topics, but it would also affect the entire human activities (Butterfield 1957). Illuminati at the time tried to change Christian recognition of nature and social recognition by the general public with modern sciences based on rationality.

In the nineteenth century, natural sciences advanced internally at an enormous speed. Physics, chemistry, biology, and geology especially shaped up their own independent scholarship fields (Butterfield 1957). In France, in fact, a number of independent academies started their activities: Académie Nationale de Pharmacie (French National Academy of Pharmacy) in 1803, Société de Géographie (Geographical Society) and Société d'Histoire Naturelle de Paris (Paris Natural History Society) in 1821, Société géologique de France (France Society of Geology) in 1830, and in 1843, Société de Chirurgie de Paris (Society of Surgery). They were the start of specialized associations formed by scientists in the study area where they could cooperate in pursuing studies in the applicable fields, a style still carried on today. In Germany and France, modern universities for advanced education were also established. In the twentieth century, many academic fields taught today at universities founded the basics of their scholarship systems, and today, universities that carry out researches and education in each field exist over the world outside of Europe as well.

4.3 Advancement of Scholarship and Specialization

In general, scholarships are categorized into "natural sciences," "social sciences," and "humanities" (Table 4.2). Natural sciences encompass a group of scholarships that study laws of natural phenomena. Categorization in Japan often takes the form of "rikei (scientific)" and "bunkei (social sciences and humanities)." Scholarships in rikei correspond to natural sciences and those of bunkei to social sciences and humanities. Social sciences study phenomena in human societies and humanities study culture that human has created.

The idea of categorizing scholarships into natural sciences, social sciences, and humanities is relatively new. Natural phenomena like motions of the sun and stars, flow of water in rivers attracted the interest of scientists in old days. Scholarships started from pursuing truth in rules and matters that surrounded people, and in ancient Greece, it was called "philosophy." How the human hearts worked and the language that people used also caught the attention of scholars as time passed by. It was natural that we also started looking at monetary economy, law, and administration as study subjects with the development of human societies.

During the dawn of scholarship, each scholar took interest in a variety of subjects and pursued the truth. As knowledge accumulated and scholarship made progress, the scholars turned their interest into more profound realities. The subjects that each scholar studied gradually narrowed down into specific areas, and scholarships headed into diversified specific areas. Table 4.2 shows the general scholarship areas. Engineering today are further divided into, mechanical engineering, civil engineering, electrical engineering, chemical engineering, and so on. Further, the scholarship of mechanical engineering is split into a number of specialized areas of fluid dynamics, thermodynamics, strength of materials, and so on. Fluid dynamics alone can also go under finer divisions. Scholarships today have gone through

Table 4.2 Categorization of scholarships

Scientific category	Primary scholarship fields
Natural sciences	Physics, chemistry, biology, astronomy, medicine, engineering, ...
Social sciences	Economics, operation research, law, sociology, administration, education, ...
Humanities	Psychology, history, linguistics, religion, literature, philosophy, ...

division after division with the advancement of what to study and research, and the trend will probably continue that way in the future.

As scholarship advanced, "specialists" that study specific areas in detail increased. A single specialized area, however, can only apply principles and law to a narrow range, and specialists have hard time applying their skills or creating new concepts. This led to new ways that are catching the attention of training human resources that have one detail specialty but also basic knowledge over a wide area. Tom Kelley and Jonathan Littman call this type of person "T-shaped" to distinguish them from "I-shaped" people that thoroughly study single areas (Kelley and Littman 2000). Those with wide basic knowledge over a wide area with two or more specialized subjects are called "Π(Pi)-shaped" people. Here, "I," "T," and "Π" are not the first characters of English words, but they are selected for their shapes representing the concepts. You can understand that the length of the horizontal bars represents the wide knowledge and vertical bars the number of specialties.

Whether "T-shaped" or "Π-shaped," the width of the basic knowledge was thought to stay within a certain range. Leaders of corporations, local or central governments, however, have to understand to a certain extent of all areas, e.g., economics, law, and physics, to give directions when needed. Solutions for detailed problems can be left to specialists in the areas; thus, the knowledge in each scholarship area does not have to reach so deep. Leaders are required to have knowledge over a wide area in the real sense that is not framed within the system of scholarships in Table 4.2, that is, the qualification for a "generalist." The advancement of scholarship led to specialization in each specific scholarship area; however, the society today needs generalists having knowledge over a wide range of specific areas and being able to give proper directions to real specialists in each area.

4.4 Births of Safety Engineering, Disaster Science, and Risk Analysis

This section overviews how specific fields related to societal safety sciences, i.e., safety engineering, disaster science, risk analysis, and so on were born. As we explained in Sect. 4.2.2, the medieval Europe saw huge advancements in science called "scientific revolution." In England, "industrial revolution" started to take shape in the mid-eighteenth century. The industrial revolution gave leaping steps forward for scientific technologies and, however, also caused accidents at levels never expected before. James Watt's (1736–1819) steam engine is often quoted as a symbol of industrial revolution. The steam engine is a machine that converts thermal energy of steam into mechanical power. The steam engine allowed machines to produce huge forces and transfer ships and railway cars at high speed. The strong machine and fast-moving transporters caused disastrous accidents when human body contacted them in wrong ways. As the number of accidents rose, people turned conscious about safety and the concept of industrial safety was born. Then it was followed by the scholarship of safety engineering that sought ways of preventing accidents and disasters. Not only to design and produce safe machines, researches on the psychology of safety and laws to keep the societies safe are developed as well.

Human already knew about dangerous natural phenomena of earthquakes, typhoons, flooding, and lightning and planned to protect safety of their way of living before social disasters entered their lives with the advancement of scientific technologies. Back then, however, without the knowledge of how natural phenomena took place, human had to protect themselves with empirical methods. In fact, plate tectonic theory was developed only in the late 1960s. Observation balloons went up in the sky in the 1930s; however, we had to wait till 1960 to hear about weather satellites. Thus, it took "disaster science" a long time to make its way into the system of scholarships. Engineering technologies and social scientific studies can now protect human lives and societies to a certain extent.

Risk analysis is also a relatively new field of study. Today's societies with highly advanced scientific technologies started to see complex phenomena involving health, environment, ecosystem, economics, and all other fields beyond whether matters were dangerous or safe. As the concept of risk with uncertainty is ever more important, the "Society for Risk Analysis" was established in the USA. The societies today are subject to a variety of risks, and it is called "Risk Society" (Beck 1986). When we recognize events of traffic accidents, NPP accidents, natural disasters of typhoons and earthquakes, safety of food, and financial crises from the viewpoint of risk, our societies must now deal with them in an intelligent manner.

The advancement of scientific technologies made our lives rich; however on the other hand, we are faced with a variety of risks and safety concerns of large-scale disasters, concerns about resources, energy, and the environment that come with corporate activities, traffic accidents, and terrorism attacks. For us to build safe and secure societies is one of the most important problems to solve, and for that goal, we need to pursue research, take practical actions, and educate human resources. Problems with safety and security, however, are often hard to solve with a single force in a traditional field of specialized area. In search of solutions for safety and security issues of today's society, we have to build a new area of scholarship that gathers wisdom from a number of specialties.

Today, scientific technologies are deeply related to our society, but some scientific problems cannot be solved within the realm of science alone. We can pose questions to science in such situations; however, science alone cannot provide answers to them. The state is generally called a trans-scientific situation (Weinberg 1974). Issues related to safety and security often are trans-scientific. Solving a trans-scientific problem involves not just scientists, but citizens, as a stakeholder, have to take part in making decisions. Problems with safety and security directly relate to life and property; thus, we cannot leave them to decisions by others, and we cannot stay indifferent. We have to face the need to educate human resources with good knowledge in societal safety issues to solve the variety of safety and security problems in today's societies.

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Part II
Events That Threaten Human and Its Societies

Chapter 5
Human, Nature, and Artificial Products

Mamoru Ozawa

Abstract Nature and societies that surround us are full of hazards. Depending on their intensities and surroundings, they develop into incidents. What artificial facilities are around, what actions people involved take, and states of societies or nature can further turn them into accidents or disasters. Risk management is ever more important for controlling such development and minimizing damages. This chapter overviews how hazards develop into accidents and damages and discusses several topics in risk management.

Keywords Hazard · Heinrich's law · Incident · Risk evaluation · Risk space

5.1 Environment That Surrounds Human and Societies

We, humans, since our first existence on the earth, have formed societies under certain sets of rules in the natural environment. The industrial revolution at the end of the eighteenth century triggered development of large-scale factory production systems, as well as power generation systems, systems for electricity generation and distribution, and so on. Once the transportation networks formed with steam-powered ships and railways, the human societies turned into somethings fundamentally different from what they used to be. The spread of factory production systems caused problems with health management and safety measures for factory workers, and in the mid-nineteenth century, England passed the Factory Act. Also as marine transportation turned active, people came up with ship inspection systems and marine insurance systems in case of marine accidents. Further for power generation systems, as people aimed at developing higher efficiency boilers, many of the efforts resulted in explosion accidents leading to boiler inspection systems by third parties.

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As the industries advanced, transportation and logistics turned large-scaled, and today people and freight travel the world. Growth of computers and network technologies has now made high-speed transfer of large amounts of information across countries giving us great conveniences. Faster transportation and logistics, however, were factors that caused worldwide spread of food safety problems like mad cow disease (bovine spongiform encephalopathy, BSE) or pandemics. The quick information communication technologies have led to frequent problems of personal information leakage and harmful rumors.

The radius of the earth is about 6500 km, and the earth crust where we live in or on is only about 30 km thick. The theory of plate tectonics says the earth surface is covered by ten or so plates, and the mantle flowing underneath them moves in various directions. Japan, at the boundary of the Eurasian and other plates, is often shaken by major earthquakes caused by sinking of the plates.

Mountains cover about 70% of Japanese land, and since the ancient time, people lived and produced along rivers or near the oceans. Advancements of societies and economics caused people to concentrate in cities, where they cut and flattened mountains, filled lowlands, and built housings. As more people concentrated to cities, agricultural regions in the mountains are now facing depopulation and economic gaps with urban regions. We are living in an environment as a result of intertwinement of natural, societal, and historical factors.

5.2 Hazards in Natural and Social Environments

We will next explain about hazards in the natural and social environments with some examples. Large-scale inter-plate earthquakes or direct earthquakes cause large damages to the infrastructures, railways, and road networks. When tsunami waves follow them, like in the case of the Great East Japan earthquake, they cause large casualties as well as major damages to power plants and port facilities in coastal areas. An earthquake is a phenomenon of a rock bed shifting caused by relative motion between plates and fault activities; thus, force on the rock bed is the hazard in case of an earthquake. Concentrated heavy rainstorms directly cause sediment disasters, frequently taking place in recent years. If we, however, review the mechanisms of sediment disasters, housing development and forest damages weaken the water retention capacities of soil and the imbalance among inter-ground friction, and viscosity and gravity on ground are factors leading to sediment disasters as well. The hazard for sediment disasters is lower friction caused by rainfall.

In large cities, electricity grid wiring and gas and water piping are congested, and in addition, information, logistics, and transportation networks are overcrowded at high speed. These situations lead to small incidents triggering large catastrophes with huge damages. The 1977 passenger plane collision in Tenerife, Spain, and the 1985 airplane crash near Mt. Osutaka in Japan both ended up with over 500 casualties. Major NPP accidents include the 1986 Chernobyl plant explosion in former Soviet Union and the 1979 Three Mile Island (TMI) accident in the USA. In Japan in

March 2011, multiple cores melted down at Fukushima Daiichi NPP. With these accidents, using high-density energy is the hazard hidden in today's social environment.

5.3 Development of Hazards into Accidents and Disasters

Hazards expose themselves as incidents, depending on their intensities and environmental conditions around them. Incidents turn into accidents or disasters with casualties or property damages depending on the facilities around them, how people reacted to them, or social systems or natural environment that surrounds them.

In April of 2005, West Japan Railway had a derailing accident on the Fukuchiyama Line that caused 107 casualties. When the train passed through a curve, rotational moment due to the centrifugal force being a function of running speed exceeded rotational moment from gravity, and these physical factors led to derailing and overturn of the passenger cars. People that live along railway tracks and passengers are exposed to dangerous situations with railway cars or tracks that are not fully maintained, troubled train drivers, improper automatic train stops or fail-safe equipment, lack of frictional force between the tracks and wheels caused by rain, and many other factors that lead to incidents. Especially, when the cars are packed during the commute time, and when the train is speeding, like in the case of Fukuchiyama Line accident, the incident develops into an overturning accident with a huge number of casualties.

Infrastructures and industrial products consist of a large number of parts and elements, sensors, computers, and software that control them. If we count a very large-scale integrated circuits that compose the computer, we understand that our societies today are built on an extremely huge number of elements that construct hierarchical systems. For such complex systems, predicting processes or scenarios that cause hazards to turn into incidents and finally into accidents is extremely difficult. Even Space Shuttle Challenger, with sufficient safety measures, exploded immediately after its launch when the simple part O-ring failed. For this accident, the operation made the mistake in business decision of prioritizing schedule despite warning from engineers who had recognized the trouble with the O-ring. Organizational management and human factors place large effects on accidents and natural disasters when hazards turn into incidents and eventually into accidents or disasters.

5.4 Risks for Evaluating Accidents and Disasters

As ISO defines (ISO/IEC 2014), the combination of damage level and frequency determines the risk magnitude. Setting the frequency F_i of incident i, and the level of damage D_i,, the next equation evaluates risk R_i;

$$R_i = F_i D_i \tag{5.1}$$

This equation is an example of evaluating risk, and some evaluations define risk with the magnitude of damage alone and others with the probability of occurrence.

Chapter 1 discussed deterministic risk assessment and probabilistic risk assessment. Deterministic risk assessment evaluates risk with whether the safety meets the standards determined by evaluation guideline and tolerance based on scientific evaluations, technical discussions, or past experiences. Many of general safety standards, like those of nitrogen oxides (NO_x) and particulate matter (PM) in automobil exhaust gas, and aseismic standards are based on deterministic risk assessment.

On the other hand, the study known as Rasmussen Report "Reactor Safety Study – An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants" (U.S.NRC 1975; Lee & McCormick 2011) established the probabilistic risk assessment (PRA) methodology. The report evaluated risks with the magnitudes of effect and annual occurrence frequencies. In general, upon event that causes an accident, there is some time delay for the effects to propagate to related parts and elements, and the delay can cause the event to develop into another event. Rasmussen Report was a breakthrough at the time in that it developed a model that simulated dynamic system response to take this time delay into account. PRA is applied not only for risk assessment of NPPs but also for aerospace industries.

Risk assessment quantifies the smallest danger as risk, but at the same time, it tolerates certain levels of risk (Slovic et al. 2000); however, clarifying which risk to tolerate under what conditions is difficult. For example, WHO states the guideline for water quality requires that the probability of waterborne diseases is below the set standards, specialists to make judgment, and administration and majority of the public to accept the quality (Hunter and Fewtrell 2001). The requirement of being accepted by the public is a judgment standard along human psychology and is not based on scientific roots. What universally applies to risk evaluation is statistic numbers, like probability of occurrence.

H. J. Otway and R. C. Erdmann reported (Otway and Erdmann 1970) that if the death count is less than 10^{-6} per year, people do not take big interest in the risk thinking they will not get caught by it. When the count, however, reaches $10^{-4} \sim 10^{-5}$ a year, they turn active in reducing the hazard and will accept inconvenience to a certain extent to avoid the risk. Further at about 10^{-3} a year, they no longer accept the risk and take immediate actions. There is, perhaps, no clear reason why people accept the death rate of 10^{-6} a year, i.e., one out of a million a year. É. Borel, however, in his 1943 book, (Borel 1943) wrote that the chance of 10^{-6} (i.e., a little less than 3 out of 2.8 million, the population of Paris back then) is something that people would accept. The current world population is about seven billion, and for this size population to match Borel's victim count, the probability has to drop to $10^{-9} \sim 10^{-10}$ a year. This example means simple probability calculations do not reach judgments and the population size matters. The count of 1 out of 1 million is just a statistical number, and the situation surrounding each case is not taken into account. We tend not to pay much attention to accidents in remote locations; however, if it involves a neighbor or a family member, we suddenly turn intolerant. Whether we tolerate a risk or not is not just a matter of probability, but it also heavily involves time and spatial distance. Further detail can be found in, for example, P. Slovic's book (Slovic 2000).

5.5 Problems That Are Common to Accidents and Disasters

Each event of accident or disaster is an unusual event with different situations in the event itself, its cause, and surroundings. If we, however, neglect the special circumstances with them and relate the level of damage with the chance of occurrence, the probability distribution shows that large-scale accidents and disasters have small odds of happening, whereas small and minor events break out frequently. A typical example is "Heinrich's law" by H. W. Heinrich (Heinrich 1931) about industrial accidents in places like factories. It stated that among 330 incidents of the same type, 300 nearly escaped actual damages, but 29 cases involved minor damage, and 1 case had a major damage. Heinrich also pointed out that behind the 300 cases without injury, there were thousands of unsafe actions and situations.

Heinrich's basic idea was that we cannot change the structure leading to accidents and disasters; however, by reducing unsafe actions, situations could lead to less disasters without injury and at the same time decrease the numbers of accidents with minor injury and those with major consequences. We often refer to the 300 cases without injury "close call" events. Heinrich's law is applied to other fields like medicine or railway, and it is a basic concept for today's accident prevention measures.

The second characteristic about disasters is that accidents and disasters develop over time; however, they do not keep spreading forever. Automobile or airplane accidents happen in split seconds; however, an event at a nuclear plant takes hours to develop into an accident. Epidemics, at the beginning, start with a small number of patients, and the number of affected grows because of contact with the infected; however, over time, the infected will either cure or die, and the number of infected does not keep growing. In case of natural disasters as well, earthquakes are phenomena that happen over short periods, and in some cases, aftershocks can take long time to subside. Tsunami and heavy rain, on the other hand, have some time allowance until the most severe situation arrives; thus, guided evacuation at the right time can reduce the number of casualties. The time scale of accidents and disasters are important factors to think about in planning disaster management.

Thirdly, accidents and disasters are not self-contained. That is, those that avoided direct hits of accidents or disasters still, sometimes, suffer from related damages. The Great East Japan earthquake had a total count of 18,458 of dead and missing, among which, as many as 3331 were related deaths due to evacuation-related health matters like stress. We need to plan against related deaths when we plan countermeasures against accidents and disasters.

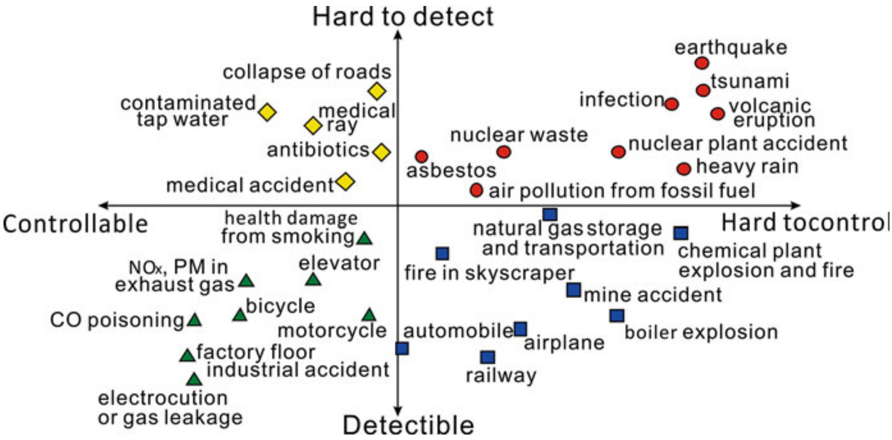

Fig. 5.1 Risk space. (Based on Slovic 2000)

We can put accidents and disasters in large categories depending on whether their occurrences are detectible beforehand or not; whether the events are controllable or not; whether their effects are within a short time period or they last over a long period, if the damages are local or over a wide area; or whether their damages can easily be removed or not. Among these factors, Fig. 5.1 picked out two and plotted different type accidents on the 2D plane, the risk space. Figure 5.1 took controllability for its horizontal axis and detectability for the vertical. The axes are free to pick depending on the discussion topic. The plots in Fig. 5.1 carry some arbitrariness in them. One may want to apply data from questionnaires to the general public or specialists or otherwise use risk numbers from rigorous risk assessment. In general, events in the first quadrant with difficulties in detection and control have high risk. Earthquakes, tsunami, and heavy rain are out of control, and their prior detections are difficult so they lie in the first quadrant. The target events are not only those in the first quadrant, but central theme for risk management is to understand characteristics of various hazards and find effective countermeasures to prevent them from growing into incidents to accidents, disasters, and major disasters and to minimize the damages.

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Chapter 6
Natural Disasters

Koji Ichii, Yoshinari Hayashi, Tomofumi Koyama, and Tomoyuki Takahashi

Abstract Natural disasters are damages to human lives or social activities caused by dangerous natural phenomena. This chapter quickly reviews the history of natural disasters, specifically for earthquakes and volcanic disasters, ground and sediment disasters, and water disasters, and discusses the mechanisms of how they break out and the typical damages they cause. Then the chapter explains predictions and countermeasures for disaster management.

Keywords Earthquake · Global environment · Ground disaster · Sediment disaster · Tsunami · Typhoon · Volcanic eruption

6.1 History of Natural Disasters in the Japanese Islands

6.1.1 Disaster Environments of Japan

Natural disasters break out when natural phenomena of earthquakes, volcanic eruptions, typhoons, heavy rain, or snow avalanches release large energy within short time periods to affect human living environments. Whether a natural disaster takes place or not depends on global environment, geographic conditions, sinking, lifting, and rising of tectonic plates and relative positions among oceans and land. The global environment is constantly changing; however, the time it takes to make visible changes is much longer than the average life span of human. This means that within a timescale of several tens of thousands of years, typhoons and earthquakes repeat at roughly the same locations.

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The islands of Japan, when compared to other regions of the earth, are surrounded by an environment where natural phenomena can easily cause disasters. The Pacific plate and Philippine Sea plate sinking under the ocean near Japan cause mega-thrust earthquakes. Tectonic plates that dive under Japan islands push the continental plates to cause inland crustal earthquakes at active faults. The sinking plates also produce magma underground and trigger volcanic eruptions.

Japan also sees a heavy average precipitation and the rain concentrates in the rainy season and typhoon seasons easily causing water disasters like flooding and storm surge. Furthermore, the Japan Sea between the Eurasian continent and Japan islands supplies plenty of moisture to the seasonal wind from the continent dropping heavy snow along the Japan seasides of the islands. The accumulated snow can cause snow avalanches and even landslides in early spring with rises of underground water levels.

6.1.2 Natural Disasters Up to the Mid-eighteenth Century (End of Edo Era)

With the geological conditions, we must say Japan cannot avoid outbreaks of earthquakes, volcanic eruptions, typhoons, and so on. These natural disasters have repeatedly attacked the islands since human started inhabitation on them. The ancient history books of Japan like *Nihon Shoki* (the oldest chronicles of Japan, Aston 1896) even noted such events. History books tend to record earthquake and tsunami damages over wide areas. Kyoto, which used to be the center of government administration and culture for a long time, has a large number of disaster records in its archives. “Nankai (south sea) trough earthquakes” break out in locations relatively close to Kyoto, and a number of disaster records have accumulated over the years.

The oldest Nankai trough earthquake on record is the 684 “Hakuho earthquake.” *Nihon Shoki* recorded damages that buildings collapsed over a wide area, tsunami waves washed away many boats, rice patches in the land of Tosa (now Kochi prefecture) went underwater with land subsidence after the earthquake, and hot springs in the land of Iyo (now Ehime prefecture) stopped coming up. These are typical damages with Nankai earthquakes with epicenters off the shore of Shikoku. Records show that earthquakes in Heian and Edo eras caused similar damages to the area. If we follow the timeline, we find that the earthquakes repeated in the same area every 100–200 years. The concept of plate tectonics in the 1960s clarified the mechanism of plate subduction causing large earthquakes to repeat in cycles. The entire world knows about Nankai trough earthquakes as a typical example.

Volcanic eruptions typically leave large amounts of volcanic ashes and lava on the ground surface. Affected areas often suffer over long times for removing the debris and from frequent soil disasters caused by them. Well-known volcanic eruptions are the 1707 Mount Fuji and the 1783 Mount Asama. When volcanos near the coast erupt, the sector collapse can cause tsunami. History books record major large-scale tsunami disasters at Oshima-Oshima in Hokkaido in 1741 and the 1792 Unzen Mayuyama collapse causing tsunami in the Ariake Sea.

Since the old days, people have made major civil engineering works to actively control water disasters. Singen-zutsumi (Kasumi Bank) in Kamanashi River in Yamanashi prefecture and project of shifting the Tone River flow to the east have traces of their major work still left today. Civil engineering works to manage water damages have the purpose of "flood control." Forcing rivers to reconfigure often have positive effects of promoting traffic, enhancing agricultural productivity, or building military barriers in addition to preventing disasters.

6.1.3 Natural Disasters in the Mid-eighteenth Century (Meiji Era) and After

In the Meiji era, the government prepared disaster measures under a single national standard and also collected statistical data about disasters and started to form regulations about them. Since then, major earthquake disasters that caused 1000 or more fatalities occurred 13 times in the islands of Japan. Especially the 1891 Nobi earthquake, the 1923 Great Kanto earthquake, the 1995 Great Hanshin-Awaji earthquake, and the 2011 Great East Japan earthquake greatly affected earthquake measures after them.

Nobi earthquake was the first major disaster for modern Japan. The number of victims totaled 7273, and a large number of brick buildings and bridges built with imported Western technologies collapsed. This earthquake moved the government to establish the "Imperial Earthquake Investigation Committee" in 1892 to systematically study the mechanism of earthquakes and research ways of preventing earthquake disasters.

The Great Kanto earthquake was the worst earthquake disaster in Japan that killed over 105 thousand people. Severe fire damages took place in the cities of Tokyo and Yokohama, and the sum of fire-caused fatalities amounted to 90 thousand for the 2 cities. Cities during this time had wooden houses packed together with extremely high population densities. The disaster made people and the government realize the importance of city planning to keep some open space and wide roads, and schools next to public parks started to form with the reconstruction plans.

The Great Hanshin-Awaji earthquake was a major earthquake about 50 years after the 1948 Fukui earthquake. This earthquake marked a large number of building collapses, and over 80% of the deaths and missing immediately after the quake were caused by crush or suffocation. Water supply, electricity, and public transportation were cut off revealing the extreme vulnerability of urban areas against earthquakes.

The Great East Japan earthquake was triggered by the largest earthquake with Mw9.0 near the islands of Japan on record. The mega-thrust earthquake at the plate boundary caused extremely huge tsunami waves. After this earthquake disaster, earthquake measures on the table now generally assume earthquakes larger than those on records.

Since the Meiji era, the number of major volcanic eruptions is relatively small. The biggest was the 1888 Mount Bandai (Fukushima prefecture) mountain collapse that took lives from 477 people. One in recent years that we probably remember is the 2014 Ontakesan eruption with death toll of 63. During the 1986 Izu-Oshima eruption, the 2000 Mount Usu eruption, and the 2000 Miyake island eruption, the administration successfully evacuated the residents temporarily. Volcanic eruptions often come with early symptoms. The 2000 Mount Usu eruption caught much attention as a successful example of predicting volcanic eruptions.

During the time immediately after World War II, many weather-related and water disasters took place. The 1945 Makurazaki typhoon and the 1947 Kathleen typhoon attacked only 2 years apart, and each caused over 1000 dead and missing. The 1959 Ise Bay typhoon caused storm surges that attacked the zero-elevation area in Nobi Plain. This typhoon caused 5098 deaths and led to the regulation, "Disaster Countermeasures Basic Act." The 1982 Nagasaki heavy rain, the 2000 Tokai heavy rain, and the 2011 Kii peninsula flooding followed. In recent years, the out-of-control land usage with urban area development magnified the damages, and economic damages spread to even wider areas with the destruction of supply chain; we started to see new facets of disasters that measure beyond damage to human bodies (Cabinet Office 2014).

6.1.4 *Changes in Disasters Caused by Changes in Social Environment*

Areas inhabited by people are rapidly growing with the growth in population (Christian et al. 2013). Japan, from the latter half of the Edo era to the early twenty-first century, saw rapid growth of population, and people kept moving onto landfills along the coast or carved out land where no one used to live. Also, with the development of globalization, supply chains in businesses are spread over large areas in and out of the country. Today, a fire in a single factory can cause effects that propagate throughout the entire world. Devastating natural phenomena like earthquakes catch our attention in terms of natural disasters; however, we also have to recognize that changes in people and societies are expanding the damages into other aspects that surround us.

6.2 Earthquakes and Volcanic Eruptions

6.2.1 Mechanisms of Earthquakes and Volcanic Eruptions

An earthquake is a phenomenon of underground bedrocks releasing a large amount of energy stored within them when they break in a short time period. Shifting of underground "faults" causes destruction of bedrocks, and the vibration from this shift transfers in the form of waves traveling over the surrounding ground shaking everything on the surface and underneath (Bolt 2005).

For an earthquake to break out, the bedrock has to be subject to continuous force, and it has to be sturdy enough to store the energy. Places that meet these two conditions are limited on the earth. Primary forces that deform the bedrocks are relative motions among the ten and some more tectonic plates that cover the earth (plate tectonics). Most earthquakes, therefore, break out near plate boundaries. Areas where oceanic plates dive under continental plates are susceptible to great earthquakes. Ground formations by molten rocks or magma are called volcanos, and the phenomena of magma bursting out to the ground surface, directly or indirectly, are called eruptions. Underground magma is subject to buoyancy caused by differences in its density with the surrounding rocks. Magma contains large amount of volatile material, primarily water, which separates out when the pressure drops to lower the magma density and generates the lifting force. If the magma contacts underground water near the ground surface, the water suddenly evaporates and causes steam explosion. Both great earthquakes and volcanic eruptions break out near band areas where tectonic plates sink. The reasons are sinking plates taking water deep down underground and the water lowering the rock's melting points to boost the generation of magma.

6.2.2 Earthquake Disasters and Their Transition

An earthquake shakes the ground, and artificial structures built on the ground surface and underground may suffer damage. The law of inertia tries to keep objects on ground surface where they stand, even when an earthquake moves the ground, and the objects receive force in the direction opposite from the ground movement. This force is inertia. If structures have insufficient strength to withstand inertia, they collapse and suffer damages. Inertia applies to underground structures, just like structures on ground surface. In addition, differences between movements of the ground and structures generate direct forces on the structures that can cause damages. Damages due to earthquake-caused ground movement include destruction of structures built directly above faults and those caused by earthquake-induced tsunami.

Intensities of the ground shaking are not uniform. The shaking tends to magnify on soft ground and apply large inertia on the structures. The ground properties also affect the cycle of the shaking. When the ground vibration property (natural frequency of ground) and that of the structure (natural frequency of structure) built on it coincide, resonance causes the shaking of the structure to magnify, and large inertia forces apply to the structures. The strength of structures is not uniform either. Even when stories of a building look all the same from the ground surface to high floors, the lower floors have to bear weights of the floors above them and have bigger columns and more reinforcement bars in them. When a strong tremor attacks a structure, the structure suffers damages first in its weakest point. For example, if a building has pilotis or columns to secure parking space on the ground floor, the relatively weakest ground floor suffers crashing damages.

We learned through lessons from the past major earthquakes that structures must have sufficient strengths so they do not suffer damages even in case of large inertia. The size of such inertia to assume during the design stage changes with time, and strengths of structures vary depending on when they were built. Their strengths also go down over time with degradation of the structures. In other words, sizes and strengths against inertia differ depending on location and structures, and large damages occur on structures with relatively insufficient strengths. This tendency applies not just to buildings like houses but also to bridges, subways, pipelines, oil tanks, and all other varieties of structures. Furthermore, secondary damages or their chain reactions can take pace, for example, with subway damage caused subsidence on the ground surface affecting nearby structures.

6.2.3 Predicting and Countering Earthquake Damages

Unfortunately, our current technologies cannot predict the sizes, locations, or timing of future earthquakes. Thus, we have to discuss countermeasures against estimated earthquakes that can cause large damages to the society once they break out. This process starts by estimating the ground shaking (reference earthquake motion) upon an estimated earthquake, projecting the damages to existing structures (evaluation of seismic capacity), and installing necessary strength (seismic retrofit). On the other hand, for structures to build in the future, designers design them to keep the level of damages within tolerance (aseismic design) in case of estimated earthquakes.

Mechanisms of earthquake occurrence shall be considered in the determination of the estimated earthquakes. Locations where bedrocks receive large forces must have caused a number of earthquakes in the past. If they continue to receive large forces, many earthquakes will occur in the future as well. Strengths of bedrocks also depend on sizes (magnitudes) of earthquakes; thus, magnitudes of past earthquake contribute to making estimations of sizes of future earthquakes.

In general, the shaking intensity reduces with distances to structures (attenuation). Therefore, assuming earthquake magnitudes allows estimating the ground shaking intensity with the distances from the structures of concern to the location of earthquake (location of the fault) and the properties of the ground where they are built (soil classification). The transmission of earthquake waves in the ground, however, is quite complex, and in recent years, more scientists estimate ground shaking at structural locations using sophisticated computational methods.

Once the ground shaking estimations are available, the magnitudes of inertia on the structure are found and comparing them to the structural strengths lead to estimating damages from earthquakes and their levels. If the analysis leads to intolerable damages, countermeasures are taken to enhance structural strengths by adding reinforcement, changing sectional configuration, or applying different materials.

6.2.4 Volcanic Eruptions and Their Transition

Phenomena that cause damages from volcanic eruptions include drop of volcanic rocks, deposition of volcanic ash, pyroclastic flow, lava flow, outburst of volcanic gas, and so on. Debris bursting out from volcanos are at high temperature and flow down from the volcano body toward lowland with large energy. When these “flows” reach areas where people live, they cause volcanic eruption damages. Different viscosity of magma causes different scenes of damages. Volcanos with less viscous smooth magma often squirt out lava flows. Those with high viscous magma tend to have explosive eruption with large amounts of volcanic ashes and cause pyroclastic flows. The caldera of Mount Aso in Kyushu is the sign of the huge eruption with debris scattered over distances of several hundreds of kilometers.

At times, the same volcano can show different types of eruptions. For example, the 864 Jyogan eruption of Mount Fuji caused lava flows, whereas the Hoei eruption in 1707 burst out volcanic ashes and pumices from a crater that opened on the volcano side. Debris accumulated around a volcano are unstable and can cause the volcano body to collapse upon earthquakes or small eruptions. The 1888 Mount Bandai eruption and the 1980 eruption of Saint Helens in the USA are such examples. The 1985 eruption of Nevado del Ruiz in Columbia suddenly melted volcano-top glaciers all at once and caused huge lahars that took 23 thousand lives.

Large-scale volcanic eruptions, in addition to the direct damages described above, are known to cause global climate changes. Volcanic gas and ashes from large eruptions reach the stratosphere to block solar energy from reaching the earth surface. This lowers the average temperature over the entire globe and causes poor crop harvest and food shortage. Eruptions of Laki in Iceland in 1783, Tambora in Indonesia in 1815, and Mount Pinatubo in the Philippines in 1991 are typical examples of such damages.

6.2.5 Predicting and Countering Volcanic Eruptions

Before volcanos erupt, the rise of magma toward the earth surface often causes abnormal phenomena. Administration has established organizations for disaster prevention by evacuating people beforehand by detecting signs of eruptions through constant monitoring of bedrock movement, electromagnetic changes, abnormal heat generation, volcanic gas, and so on.

The Japan Meteorological Agency constantly monitors 50 volcanos among the 110 active ones throughout the country. The Cabinet Office of the Government of Japan has established "Volcano Disaster Management Councils" for 38 of the 50. Each council consists of prefectural and local government officials, meteorological observatory personnel, the Sabo (Soil Erosion Control) Department, and volcanologists to discuss evacuation at times of no threats to prepare against eruption. These volcanos have eruption alert levels to announce eruption warning and forecasts in coordination with local evacuation plans.

At the time of the 2000 Mount Usu eruption, the work of Professor Hiromu Okada of Hokkaido University (at the time) known as the "home doctor of Mount Usu" succeeded in predicting the eruption and evacuating the residents in the area (Okada 2007). At the time of the 2014 Ontakesan eruption, however, the size of precursors was small, and the prediction failed leaving 63 dead or missing. It was the worst volcano disaster in Japan after World War II.

6.3 Ground and Sediment Disasters

6.3.1 Types of Ground Disasters and Mechanisms of Their Occurrences

There are two types of ground disasters: those that break out on plains and landfills and others that take place in hills and mountainous areas. The former type includes subsidence due to consolidation of clay ground, wide area subsidence caused by extraction of groundwater, and liquefaction of sandy ground. Landslides caused by earthquakes and heavy rainfall are of the latter type. Although different in nature from these types, the new concerns of underground disposal or storage of industrial waste including radioactive nuclear waste are, in a broad sense, also ground disasters.

Soil that make up the ground has the structural skeleton formed by solid grain particles contacting one another and pore filled with air or water or in cases with oil. Ground disasters break out when pore water that fills pore inside the grain particle formed structural skeleton changes within the ground. Structures built on clay ground change the load inside the ground, and pore water is squeezed out over a long time period causing ground subsidence. When pores filled with water reduce their volumes due to pumping out of the groundwater, ground subsidence also takes place. Liquefaction, on the other hand, is caused when the earthquake force takes away resistance in loosely packed sandy ground filled with water and turns the ground soil into a liquid-like state. The earthquake shakes the ground giving rise to the pore water pressure, and the soil particles lose their contacts with one another disintegrating the particle-formed structure, and the particles start to flow in the form of muddy water.

On slopes, earthquakes and heavy rain trigger sediment disasters. The next section discusses types of sediment disasters and how they happen. The groundwater flow that fill pore raises concerns about dispersion and diffusion of contamination from underground waste.

6.3.2 Types of Sediment Disasters and Mechanisms of Their Occurrences

Sediment disasters is a collective term for debris flow, landslides, hillside collapses, and so on that are caused by the movement of earth and soil. Debris flow is a flow of mud with high content of rocks and stones, and it is called a mudslide when the flow mainly consists of finer mud, sand, and pebbles. Debris flows can be caused by hillside collapses induced by heavy rainfall or riverbeds with stones and soil suddenly lifted by increased river flows that push them all downstream. Although theory about physics of debris flows have been clarified, predicting when, where, and how big they will be is difficult. Landslides and hillside collapses are phenomena of big chunks of soil and rocks sliding down with gravity. Landslides, in general, are mild slopes moving slowly, however, over wide areas. In many cases, grounds that slipped in the past often start sliding again. Special land configurations called landslide formations can form on ground surfaces. Hillside collapses, like cliff collapses, are relatively smaller, and they are concentrated collapses of steep slopes on mountainsides caused by heavy rainfall or earthquakes. Hillside collapses break out during the rainfall or within a relatively short time from the end of rain; however, landslides often continue for long times even after the end of rain. Understanding them takes not just knowing infiltration of rainwater but also long-term flow of groundwater.

Soil and rocks on slopes receive strong sliding forces from gravity trying to push them down the slopes induced temporarily by earthquakes or added weight with rainwater infiltration. On the other hand, vertical movement from earthquakes can lower the vertical stress, and rainwater infiltration can raise the pore water pressure to lower the effective force on the structural skeleton of soil particles. These phenomena lower the frictional resistance at the “slip plane” between the stable layer of slopes and chunks of soil and rocks. When the sliding force overcomes frictional resistance at the slip plane, a landslide or a hillside collapse breaks out.

The huge landslide at Xiaolin Village in Kaohsiung Taiwan in August 2009 triggered attention to deep-seated landslides. Differently from shallow landslides of slope surfaces with weathered depositions, deep-seated landslides are major collapses that take bedrocks at deep underground with them. Shallow landslides occur with heavy rainfalls in short time periods, and in contrast, deep-seated landslides break out when the accumulated rainfall reaches 400–500 mm over long time. During the September 2011 Kii Peninsula heavy rain, deep-seated landslides took place over a wide area in Nara and Wakayama prefectures, Japan, and caused serious damages.

6.3.3 Ground and Sediment Disasters

Main damages caused by ground and sediment disasters are the following. Subsidence causes structure to tilt, generates steps on the ground, and increases the risk of flooding. Liquefaction causes structures to sink or tilt and can cause underground structures to come up to the ground surface. Levees can sink or their bodies can shift to the side. Landslides can cause loss of lives or properties and can destroy houses.

In recent years, people are more concerned about compound disasters like earthquake, liquefaction, and tsunami all occurring at the same time, or heavy rain causing landslides and flooding. During the March 2011 Great East Japan earthquake in Japan, the earthquake caused liquefaction, and coastal structures like seawalls or river levees lost their functions when the tsunami hit the area to mark huge damages. The September 2011 heavy rain in Kii Peninsula caused huge landslides that blocked rivers and formed natural dams. There was high risk of these natural dams collapsing that would have caused major outburst floods in the downstream areas.

6.3.4 Preparations for Preventing Ground and Sediment Disasters, Measurement, and Monitoring

Measures for ground and sediment disaster prevention include both hardware and software. Hardware measures against debris flows include embedding soil retaining structures to stop collapse of unstable slopes and prevent lumps of earth from moving, or building soil-blocking dams in the downstream of rivers to stop debris flows or to lessen their energies. Software measures, on the other hand, include enforcing regulations that restrict housing development in areas where sediment disasters are likely (e.g., Act on Promotion of Sediment Disaster Countermeasures for Sediment Disaster Prone Areas 2000); informing residents with sediment disaster hazard maps about areas with risk of debris flows, landsliding, and hillside collapses; or issuing ground and sediment disaster warnings so residents can brace or make early evacuations. Hardware preparations so far have made large contributions in reducing ground and sediment disasters. In recent years, however, reduction in investment to public projects caused by the shrinking economy is causing administrations to shift their efforts into software. Of course, software alone cannot prevent these disasters. Especially the battle against extreme weather conditions, said to be caused by global warming, requires more efficient and effective measures by combining hardware and software measures in a balanced way. For liquefaction, a number of construction methods have been proposed and implemented including dispersing increased pore water pressure, lowering underground water level, or stiffening the ground.

Measurements and monitoring of ground and soil movements like debris flows, landslides, and hillside collapses are extremely important in predicting disaster they cause and in making early warnings and evacuations. Methods in practice include monitoring displacement and deformation of moving soil and measuring physical quantities about groundwater like water content in hillsides or pore water pressure. A large number of methods for such measurements and monitoring have been proposed; however, what and where to make measurements and monitor for the best results have not been clarified. We need to continue making measurements and collect monitoring data and analyze the data to set control standards and to reach solutions for these threats by the nature.

6.4 Hydrosphere Disasters

6.4.1 Mechanisms

Water-caused disasters like tsunami, storm surge, or flooding are called hydrosphere disasters. They are all natural phenomena that involve huge quantities of water with great energy; however, the mechanisms of their occurrences vary. Tsunami is a phenomenon that propagates a rise or subsidence of sea surface with gravity working as the restoring force. A landslide or a volcanic eruption can cause tsunami, but about 90% of them are caused by earthquakes. When a tropical cyclone like typhoon grows, the low pressure sucks up the ocean surface, and the violent wind blowing toward the coast pushes the seawater to cause storm surge. Flooding is the phenomenon of heavy rain from a typhoon or a front gathering to rivers and their sudden rises in water level pouring out into the cities.

A lump of water quickly moves in the horizontal direction than in the vertical, and all hydrosphere disasters are explained as waves with long wavelengths compared to the depth (in case of a flooding, the flood area is wider compared to the inundation). When the wavelength is 25 times or more of the water depth, the wave is called a long wave, and the governing equations (equations that describe the governing physical laws) are as follows:

$$\frac{\partial \eta}{\partial t} + \frac{\partial M}{\partial x} + \frac{\partial N}{\partial y} = 0 \tag{6.1}$$

$$\frac{\partial M}{\partial t} + \frac{\partial}{\partial x}\left(\frac{M^2}{D}\right) + \frac{\partial}{\partial y}\left(\frac{MN}{D}\right) + gD\frac{\partial \eta}{\partial x} + \frac{gn^2}{D^{7/3}}M\sqrt{M^2+N^2} = 0 \tag{6.2}$$

$$\frac{\partial N}{\partial t} + \frac{\partial}{\partial x}\left(\frac{MN}{D}\right) + \frac{\partial}{\partial y}\left(\frac{N^2}{D}\right) + gD\frac{\partial \eta}{\partial y} + \frac{gn^2}{D^{7/3}}N\sqrt{M^2+N^2} = 0 \tag{6.3}$$

where η is the water level; M and N are the discharge fluxes in x and y directions, respectively (which express the strengths of flows in the horizontal direction); D is the total water depth (sum of water depth and water level; inundation depth in case of flooding); g is the acceleration of gravity; and n is Manning's roughness coefficient (for the magnitude of friction at the bottom).

The first term of Eq. (6.1) is the rate of water level change with respect to time, and the second and third terms are the rates of discharge flux changes with respect to space. Equation (6.1) is the continuity equation derived from the law of mass conservation, and it expresses that spatial change of flow causes the water level to go up or down. The first terms in Eqs. (6.2) and (6.3) are the rate of flow flux change with respect to time, the second and third terms are the rate of discharge change with respect to space along the flow components, the fourth terms are the change of pressure with respect to space, and the fifth terms are the sizes of bottom friction. Equations (6.2) and (6.3) are the equations of motion in the horizontal directions derived from the law of conservation of momentum, explaining that the flow varies with spatial differences in flow or pressure and it decays with larger friction at the bottom.

Calculating Eqs. (6.1) through (6.3) with the computer allows simulating hydrosphere disasters. In fact, they are the equations that the central and local governments use in estimating damages and producing hazard maps. These three equations with multiplications and divisions of variables are based on the theory of nonlinear long waves and apply generally to deep ocean and to land. Tsunami warnings, however, only need predictions of waves that reach the coastlines, and nonlinear terms for shallow sea and on ground are neglected.

6.4.2 Scenes of Damages

Tsunami damages take different forms depending on where they take place. In general, tsunamis that were generated near the coast like the tsunami caused by the 2011 Off the Pacific Coast of Tohoku earthquake (Tohoku tsunami) are called near-field tsunamis, and those that reached long distances where the earthquakes were hardly sensed, like in the case of 1960 Chilean tsunami, are called far-field tsunamis. The two types are distinguished in disaster mitigation. Near-field tsunamis attack the coastal area within several minutes to several hours to cause large human damages. Far-filed tsunamis that travel across the Pacific Ocean attack a wide area with long-wavelength waves to cause large damages to the fishery industry. The coastal topography also affects tsunami damages. A ria coast has complex jagged interface between land and water, and although tsunami waves may amplify locally, the steep land in the back often limits the inundation to the coast. For flat land, tsunami waves may amplify a little because of the simple coastline; however, the wide flat land lets the waves reach far inland. For example, Tohoku tsunami inundated a wider area in Fukushima prefecture and destroyed more buildings than in Iwate prefecture with higher waves. Rivers have less resistance and friction to damp the tsunamis, and they can run up to upstream regions and cause damages to residents that are usually not worried about tsunamis.

Storm surges cause different magnitudes of damages depending on the typhoon routes and geography. Strong winds blow counterclockwise in the perimeter of typhoons, and the right side of the moving typhoon suffers from the circling wind and forward movement. Typhoons near Japan move from southwest to northeast generally. Thus, bays that face the south have openings that winds can attack and suffer big storm surge. This effect caused huge inundation damages to, for example, Tokyo bay at the time of the 1949 Kitty typhoon, Ise Bay during the 1959 Ise Bay typhoon, and Osaka Bay with the 1961 second Muroto typhoon. Global warming weakens the upward flow of air that causes typhoons, and predictions say that their number will drop. Warm vapor that is the energy source of typhoons, however, increases, and there is the risk that once they are born, they may be larger and stronger.

Global warming caused larger and stronger typhoons that will increase the rainfall with higher risks of flooding. When towns are flooded by river, flows going over the banks or destroyed levees are called fluvial flooding, whereas, flooding caused directly by rainwater and insufficient pumping or draining are called pluvial flooding. The primary cause of fluvial flooding is upstream rainfall. Thus, even when there is small rainfall in towns, flooding can take place and persist for an extended time. Inundation depths suddenly rise with fluvial flooding; thus, quick evacuation is important. Not evacuating the area or attempting to after the flooding started can cause human damages. In recent years, there is more pluvial flooding in urban areas. The inundation depths growing gradually with pluvial flooding cause less human damages; however, flooding over a wide urban area can cause large economic damages.

6.4.3 Damage Mitigation

Countermeasures against hydrosphere disasters start with assuming the external force and estimating the damages they cause. Based on these basic data, hardware and software countermeasures are implemented. Many of the countermeasures are common to all forms of hydrosphere disasters. Tohoku tsunami influenced the countermeasures against storm surge and flooding, so in the following, we will discuss mainly about countermeasures against tsunami.

Hardware preparations of building structures like seawater walls, river levees, and water gates aim at preventing water from entering residential areas. In designing structures, the designer needs to define the external force, and before Tohoku tsunami, it was the largest in history. The idea was reasonable that huge external force applies in cycles; however, the precondition was that human knows the biggest in history. Tohoku tsunami, however, showed us the fact that our limited records of history do not teach us what the largest in history was. The fact that we had a misunderstanding of knowing the biggest in history was a factor in causing huge damages beyond our forecast. With this lesson from Tohoku tsunami, we since then have set two levels of tsunami expectations: “level 1 tsunami” height with tsunamis that frequently occur from our data and maximum “level 2 tsunami” height with physical possibility even beyond our experience. Hardware preparations against level 1 tsunami aim at protecting resident’s lives and properties, and for level 2 tsunami, the preparations also involve software to protect people’s lives.

Damage estimation before Tohoku tsunami was about inundation damages, i.e., about the behavior of water. Tohoku tsunami, however, opened our eyes to all sorts of tsunami damages including building destruction, floating objects, disaster debris, and geographical changes with sand transportation. Evaluations are starting about these phenomena that accompany inundation damages.

Software preparations target properly informing the residents about risks that come with disasters and encouraging them to take proper action upon their break-outs. Evacuation is especially important in case of hydrosphere disasters, and a number of hardware preparations are also in process, like double levees (raised roads) that proved effective at the time of Tohoku tsunami, coastal protection forests, evacuation buildings and lifesaving hills for temporary evacuation, and strong seawater walls. At the time of Tohoku tsunami, the tsunami warning, indispensable for starting evacuation, underestimated the size and was a factor in causing expanded damages. Since Tohoku tsunami, therefore, enhanced monitoring and new numerical models are in the process of being in place.

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Chapter 7
Social Disasters and Damages

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Abstract This chapter discusses actual social disasters and damages they caused. The first section starts with some societal problems we face today. They are accidents due to aging infrastructures and difficulties in preventing them, nature and trends in accidents involving airplanes which are one of the most advanced industrial products today, characteristics of automobile accidents with the most serious social disasters in modern society in terms of the number of deaths and injured, and drug toxicity and safety in medical care. The following Sect. 7.2 analyzes human error, which is the most important factor in conducting analysis and investigation of accidents. Lastly, the third section closes the chapter with an overview of the history of major social disasters and their countermeasures.

Keywords Aging infrastructures · Automobile accidents · Drug toxicity · Human error · Maintenance · Safety-I · Safety-II · Transportation war

7.1 Social Disasters and Damages

7.1.1 Accidents with Infrastructures

Infrastructures are basic systems and services for countries, industries, or organizations to function effectively. For example, roads, railways, electrical grids, communication networks, ports, dams, water supply and sewage, schools, hospitals, parks, and public housing are systems of facilities that form bases for industries and social livings. In Japan, the ceiling-slab collapse accident took place in December 2012 in Sasago Tunnel on Chuo Expressway and caused nine fatalities. This accident triggered large concerns for people over aging of social infrastructures like tunnels, bridges, water supply, and sewage.

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Infrastructures are said to last, in general, 50 years; thus social infrastructures built during the high economic growth period in the 1960s have now served functions for over 50 years, and their maintenance, repair, and renewal are urgent matters. The 2014 "White Paper on Land, Infrastructure, Transport and Tourism" reports that by 20 years later in 2033, social infrastructures that have surpassed 50 years of existence will make about 67% of road bridges, about 50% of tunnels, about 24% of sewage drainage, and about 58% of harbor piers. Maintenance management and renewal cost was about 3.6 trillion yen (about 34 billion US dollars) in 2013 and is estimated to grow to 4.6–5.5 trillion yen (43–52 billion US dollars) in 2033 (MLIT 2014).

The USA, under the New Deal in the 1930s, had its infrastructures built earlier than Japan, and already their aging was a serious problem in the 1980s. Pat Choate and Susan Walter in their 1981 book *America in Ruins* warned about accidents that the aged infrastructures would cause.

In Japan, local public organizations control most of the social infrastructures. For example, among the about 730,000 bridges in the nation, about 520,000, which is over 70%, are on municipal roads, and in 2025, 44% of them will be in service for over 50 years (MLIT 2015). There are about 4000 roadway collapses caused by sewage line failures annually. This amounts to about 1.0 roadway collapse a year for every 100 km of sewage pipe (NILIM 2012). Local public organizations, thus, have the important role of maintaining, managing, and renewing social infrastructures; however, their organizations are short of what are sufficient, and they are in need for people resources and skills. Budgets for such maintenance, management, and renewal are also short. Since the Sasago Tunnel accident, managing organizations have the liable responsibilities, and "lack of personnel" or "lack of budget" cannot make reasons for not performing maintenance and management. Local public organizations have the urgent need to secure and educate technicians for maintenance and management of social infrastructures.

Social infrastructures are important factors in national resilience for disaster prevention and its mitigation. Making necessary preparations is an urgent matter so they can remain safe and serve their functions at times of disasters. For maintenance, management, and renewal of social infrastructures to meet local needs and demands of the time, efficient and effective asset management of the facilities is in need. The management should be based on mid- to long-term total and strategic maintenance plans to, for example, make preventive maintenance based on time degradation forecast. Under the circumstances of lack of budget and workforce, we need to promote development and application of new technologies that can effectively maintain and manage infrastructures, so we can cope with aging social infrastructures.

7.1.2 Accidents with Industrial Products

Industrial products include a wide variety with different sizes and uses. Gas water heaters and air conditioners for home use; machining tools like lathes for factories; transportation machines like automobiles, railway coaches, ships, and airplanes assembled in factories; large facilities like nuclear reactors, boilers, and turbines for power generation; and chemical plants for petroleum products are all industrial products. This section explains the transition in accidents about industrial products. It takes airplane accidents as the primary example because the industry has outstanding advancement in the technologies involved over the past 50 years and reliable statistical data about their accidents.

Figure 7.1 shows the number of commercial flights and their accidents over the past 55 years. As Fig. 7.1a shows, the number of flights was small in the 1960s, but with economic growth and lowered airfare, it grew roughly linearly over the years till now. The number of accidents also grew at a high pace in the 1970s but then leveled off at a rate of 10–25 a year. On the other hand, as Fig. 7.1b shows, the number of accidents per one million flights exceeded 50 per year around 1960; however, it rapidly went down to about 5 a year in 1970 or so, and since then it is maintaining a slow but gradual decline.

Through a large number of accidents they experienced, airplane manufacturers and airline companies overcame a large number of problems and advanced their manufacturing technologies and flight control systems. The introduction of computers especially made large contributions to enhancing the reliability. Even so, aging equipment and the problem of human factors persist, and the accident count does not drop to zero. This trend of accidents is not unique to airplanes and is common to all accidents involving industrial products.

7.1.3 Automobile Accidents

During the postwar period of high economy growth, automobiles spread widely in Japan, and the number of owners increased rapidly. On the other hand, building infrastructures like sidewalks and traffic lights lagged behind as well as regulations for traffic control, and deadly automobile accidents reached 16,765 in the single year of 1970 (First Traffic War). The victims back then were pedestrians, especially infants and children.

In 1970, Basic Law on Traffic Safety Measures was enacted to promote well-planned and overall safety measures for land, oceanic, and aero transportation. When the law went in effect, the administration took on building infrastructures like sidewalks, pedestrian bridges, and guardrails. Promotion of traffic safety education and campaigns reduced the number of automobile accidents and the number of victims injured or killed.

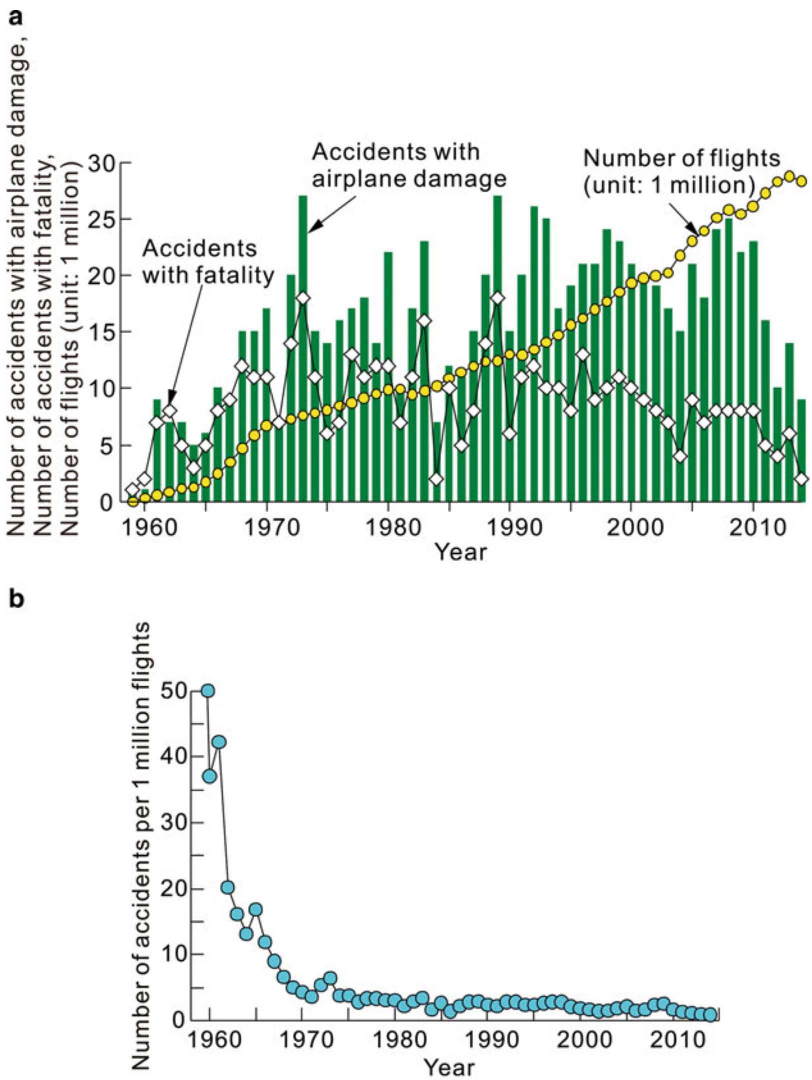


Fig. 7.1 History of airplane accidents, based on data from Airbus (2015) and Boeing (2014). (**a**) Number of accidents, fatal accidents, and number of flights. (**b**) Number of accidents per one million flights

Later, the number of automobiles kept growing, and the shortage of budget for adding more traffic-control policemen or building more traffic infrastructures of safety facilities caused the number of deaths due to automobile accidents to turn around and start growing again in 1980. Especially from 1988 to 1995, the number of deaths constantly exceeded 10,000 a year (Second Traffic War). During this period, the number of accidents by young drivers increased rapidly, and another distinct point was that the rate of those killed while in the car at the time of accident was high.

In 1996, the number of annual deaths with automobile accidents went below 10,000 and started to decrease. The number of accidents and injured, however, increased until 2004 with growing quantity of automobile traffic. Although the number of accidents increased, the development and spread of safety technologies at the time of impact, airbags and antilock braking systems, turned the vehicles safer, and regulations like mandatory seatbelts in the front seats (1992) and mandatory child seats (2000) contributed to reducing the number of deaths. Further the tighter penalty against driving under the influence, criminal charges against reckless driving leading to death or injury (2001), and continued efforts in improving automobile safety technology led to drop in all numbers of accidents, injured, and deaths.

As our society rapidly turned to an aged society, however, more than half of the automobile-caused deaths has been with elderlies at 65 or older since about 2010. As our society will grow even older in the coming years, the trend in automobile accidents will be affected, and further measures for accident prevention will be necessary.

By the way, automobiles turned into practical tools in the early twentieth century. Since then, the societies have been dealing with the social problems of driving manners and noise, in additions to accidents. The measures cover a wide range of improving vehicle performance including safety, constructing and developing technologies for infrastructures about road traffic systems, regulation and enforcement of traffic rules, and training and education of drivers and others involved with transportation.

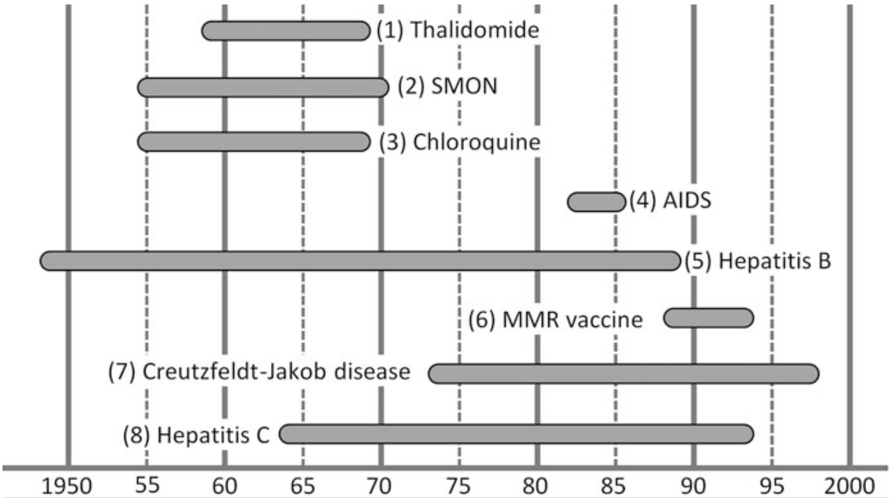
In recent years, advancement of various sensors and camera technology as well as automobile safety technologies like damage-reducing braking systems was developed, and by coordinating them with information and communication systems like intelligent transportation systems (ITS), "automatic driving" that does not rely on the driver's operations is turning into reality. Nevertheless, a number of problems still remain like the fact that a set of certain conditions need to be met for driving assistance systems to work or who is liable in case of an accident while driving with automated assistance.

7.1.4 *Drug Toxicity and Safety in Medical Care*

Throughout the history of mankind, drugs have been in use for curing diseases since the ancient times. Especially since the twentieth century, advancements in chemistry and medicine led to mass production of drugs as industrial products. Drugs have saved a large number of human lives but, at the same time, have caused drug toxicity.

The phrase "drug toxicity," in general, has a broad meaning of "damage caused by drugs"; however, in the medical and pharmaceutical fields, the phrase is specifically used for the narrow meaning of "damages caused by harmful side effects of pharmaceuticals"; however, not all damages caused by harmful side effects of pharmaceuticals are called drug toxicity. Special administration of pharmaceuticals has strong relations to this practice.

Pharmaceuticals, in principle, provide healing effects, but at the same time, their applications cause inconvenient side effects to human bodies. The extremely complex nature of human body enjoys the expected effect (primary function), however, with a number of side effects in general. Some side effects may benefit human body; however, some are harmful. A drug is a product to use carefully with knowledge of the target effect and accompanying side effects, especially harmful side effects, and apply just the right amount at the right time. Fault in drug administration is, thus, not drug toxicity but it is a medical accident. On the other hand, negligence in identifying harmful side effects of pharmaceutical and hiding or falsifying them to cause delay in response or unnecessary expansion and severity are called drug toxicity. Figure 7.2 shows major drug toxicities in Japan in the past.



(1)	Side effect of sleeping pills caused birth defects	(~300)
(2)	Side effect of stomach drugs caused walking or vision disorder	(~11,000)
(3)	Stomach pain and arthritis drugs caused retinopathy	(~1,000)
(4)	Contaminated blood products caused hemophilia, amounting to about 40% of the patients	(~2,000)
(5)	Mostly due to sharing needles during vaccination	(est. ~450,000)
(6)	MMR vaccine caused side effects like meningitis	(~1,000)
(7)	Infected by transplant of human dried dura	(~150)
(8)	Infected by contaminated blood products to treat bleeding	(est. ~10,000)

Fig. 7.2 Major drug toxicities in Japan [durations (victims count)]. (Original source: Medwatcher Japan meeting handouts. Source: Mainichi Newspaper, morning edition, Aug. 20, 2017)

Quality of drugs directly relates to safety of life; thus, in modern pharmaceutical industry, good laboratory practice (GLP), good manufacturing practice (GMP), and good clinical practice (GCP) are in place to establish high-quality safety evaluation systems that are unequaled with any other industrial product. Safety evaluation of pharmaceutical, however, takes specialized knowledge; thus, pharmaceutical companies often directly or indirectly take part in research activities that can easily lead to problems of conflict of interest with medical facilities, organizations for medical research, or academic institutes. The industry has a problem of being under the threat that social anxiety or distrust could spread with rumors that expert judgments are distorted and unfair evaluations are made.

The 2012 Diovan scandal in Japan was a typical example of such social problems. This scandal involved a pharmaceutical company employee taking part in a clinical research of his company's new drug Diovan and publishing forged data with the doctor in a paper. The result was a blockbuster (a code word in the pharmaceutical industry for a drug that led to sales of 100 billion JPY or more) among its competitors, and the profit was enormous.

In the medical field, new problems continue to arise including but not limited to drug toxicity, like safety concerns with fair drug treating. Further, with the June 2014 amendment of Medical Care Act, the system of medical accident investigation just started on October 1, 2015. Countermeasures for these problems are equally important to the safety and security of the citizens in addition to the problems we have had over the years.

7.2 Human Errors and Accidents

7.2.1 Hazardous Human Errors

Even under the circumstances when the given information is insufficient, conditions are unknown, or unexperienced people can flexibly carry out problem-solving based on experience and knowledge. When a performance has to continue, however, and for an extended period of time, people cannot continue the precise work no matter how serious they are. On the other hand, machines can repeat the same work precisely even if the work may be complex and hard as long as the expected performance is within the design and specification of the machine. When, however, information to perform the task is insufficient, or it is out of the design specification, a machine cannot carry out the work. Its work also has to be stopped in case of unexpected events.

Human can flexibly react to a variety of situations and can carry out redundant actions as well. In short, human has the characteristics of flexibility, redundancy, and variety. If we look for flexible judgment by machines in response to the situations, the ranges that they can handle have technical limitations, and they cannot meet the needs. The recent advancement of artificial intelligence (AI), however, is gradually giving machines flexibility, redundancy, and variety that human has.

Humans have demanded reliability, accuracy, and repeatability to machines and have realized them with scientific technology. Given the right specifications, we can design and assemble the machine, and by giving them proper maintenance, machines can continuously carry out the given precise performance with high reliability. There are some exceptions to human work, like cases of craftsmanship that far outperforms machines. Human ability, however, has limits both qualitatively and quantitatively, and if we ask them to perform accurate work continually, there will mostly be some level of variation.

Ever since the industrial revolution, humans developed a wide variety of technologies to cover the characteristics they lacked. The development of technologies has made our lives comfortable and effective. As long as men and machines compensated each other, there were no big concerns. The social demand for efficiency and productivity these days, however, is so high, and as people started to see AI with human-like characteristics, the demand against human for reliability, accuracy, and repeatability rose up to the level of machines or even more.

The advancement of scientific technology is also pointing at development and improvement of methodologies for human problem-solving and education and training for enhancing problem-solving skills. The human nature, however, has not made much of a difference since the birth of humankind. Therefore, when the difficulty with performance requirement is over the limitations of human, or when the abilities of the performer are insufficient or inadequate, the odds for incidents or accidents to take place go up. The concept of human error comes with inadequate action by human from inabilities or inadequate responses that leave the given task incomplete.

7.2.2 Human Errors and Accidents

We all acknowledge that “anyone makes mistakes.” In fact, anyone can be “careless” and have “mind slips” at times, and as long we are human, we can never do away with them.

The advancement and complexity of scientific technologies now demand humans to perform well above their abilities, and there have been quite a number of cases where minor mistakes developed into unprecedented major accidents or troubles. Mistakes that humans make can qualitatively and quantitatively affect the society, and as they have caught our attention, the phrase “human error” now applies to such acts. At the same time, the idea that “we can prevent accidents and troubles if we eliminate human error” is gradually gaining grounds.

Since some time before, many companies post signs that read “Safety First.” Recently another sign “Eliminate Human Errors” often makes their ways next to them. Efforts to eliminate human errors have continuously been in practice since the 1980s, and much resource has been put into them. So far, however, there have been no case of successful human error elimination, and as we will discuss next, we will not succeed in the future, either.

Posting signs that say "Eliminate Human Errors" has the thinking behind that human errors are causes of incidents and accidents and that their elimination can prevent accidents. If, however, human "carelessness" or "slip of mind" is what a human error is, we can never eliminate them. The reason is because these phenomena are part of our specification as living organisms and they cannot change unless we change the specification for human. If we take the standpoint that human errors cause accidents, once we find a human error with one involved with an accident, investigation has identified the cause, and it stops right there. Since this cause cannot be eliminated, so is the accident.

As we clarified that "human error elimination" cannot prevent accidents, measures for accident prevention are shifting toward taking human error as a result, identifying the real cause in the background, and discussing accident prevention measures against it. The idea that human errors cause accidents, however, spread first, and many organizations still spend large efforts under the target of "human error elimination."

7.2.3 Human Errors and Accident Prevention

We all acknowledge that "anyone makes mistakes." In fact, anyone can be "careless" and have "mind slips" at times, and as long we are human, we can never do away with them.

Shinnosuke Usui, a researcher in Safety Ethology, stated "the same action would, depending on the range of system tolerance, result in a human error at times, but not at other times" (Usui 1995). He further claims that the phrase human error means "When the action taken is compared with the standards required for the external circumstances and situations and if it falls outside of tolerable range, it is named" human error and that "It does not mean some special action of an abnormal nature" (Usui 2000). An aero- and astro-medical scientist Isao Kuroda defined human error as "Human action against expectation that unintendedly resulted in something different from the target goal" (Kuroda 2001). Both views take human error as results, and we can summarize human error to mean "unintended different results," "results outside of tolerable range," or "unexpected results."

Based on these ideas, we have to first analyze "what was the person's intension or goal of action at the time," "what was the tolerable range of action under the external circumstances or situations at the time," and "how big was the gap between the expected results and results of the action taken," and then we can determine what the human error was. Further, the countermeasure to make changes depends on which action is taken as human error which also depends on the point of time and level of concern throughout the series of actions.

Sidney Dekker stated that solving the problem of human error first takes understanding how the taken action systematically related to the external circumstances and expected results, and then it is important to understand, in the actor's shoes, the local rationality inside the human judgments and actions (Dekker 2002). We need to think about local rationality when we want to understand human error, in finding the cause of an accident, and in attempting to prevent the accident. Further, with the understanding of human nature, we need to continually make efforts in gaining skills for judging the contents of the required problems, skills for judging if the posed difficulty is fair, and ability to accurately detect errors with the understanding of error patterns and enhance the overall system protection, expansion, and improvement.

7.3 History of Major Social Disasters and Their Countermeasures

7.3.1 History of Social Disasters and Accidents

Human exchanges material with the nature. The process involves (1) make actions to gain resources from the nature, (2) apply work to the gained resources to produce artificial objects, (3) consume resources and artificial objects to live, and (4) after completely consumed, return what is left of the resources and artificial objects by disposing them to the nature. This sequence of processes acquires resources and artificial objects needed to maintain life as “goods” and consume them. The sequence, however, often produces some unwanted “bads.” Social disasters in the broad sense are, in a sense, “bads” produced in the process sequence of material exchange. For example, industrial bads are produced in processes (1) and (2), product and equipment accidents and accidents of infrastructures are bads in process (3), and environmental destructions are bads that can surface in all processes (1) through (4).

Industrial disasters affect the modern world in two forms: one contains the bads in the production zone, and the other spreads the bads to the surrounding regions and the whole society. The following descriptions review the history of their breakouts. Like for the case of accidents in mines, factories, or construction zones, when the damage is contained within the industrial zone, bodily damages are handled as industrial accidents. The history of coal and other mines tells us that major to minor accidents of explosions, fires, collapses, and flooding repeated. The postwar worst coal mine accident in Japan was the 1963 Mitsui Miike mine explosion that killed 458 and injured 555. This accident caused carbon monoxide poisoning to 839 and the majority suffered aftereffects. A number of large accidents followed this one.

Fires and explosions at factories made their marks also, like the 1892 Osaka Spinning Mill factory fire (85 deaths) and the 1905 Tokyo Artillery Arsenal factory explosion (26 deaths). After those, however, there have not been such factory accidents with many fatalities other than the exception of the 1970 Mitsubishi Heavy Industry Nagasaki Shipyard turbine explosion accident (a 50-ton turbine rotor broke apart killing 4 and leaving 64 injured). Industrial accidents in the manufacturing industry are mainly during the daily work, and the number of accidents has been declining since the peak around 1960. In recent years, however, the industry has to be cautious about accident that surfaced with some time delay. In some fields, a variety of chemical substances is present, and exposure to them without the knowledge of their danger can cause serious damages later. The problem of bile duct cancer with printing factory workers surfaced recently, and in the past were the problems of benzene poisoning and cancer-causing polyvinyl chloride. Health effects from asbestos have been known for quite some time; however, they have caught the general attention only recently.

Industrial disasters that affect the surrounding area and the society are caused either by accidents or in some cases the regular daily operation. A typical example of the former is the 1984 pesticide leakage from Union Carbide's plant in Bhopal, India. The toxic gas leaked out over a 5-mile area from the factory leaving 2000 dead and 300,000 injured the following day. The death toll continued to increase later in the devastated area, and health problems are still persistent as of today. Examples of the latter in Japan, on the other hand, are air or water pollution from smoke or wastewater disposal from factories. In the Meiji era (1868–1912), Ashio Copper Mine poisoning broke out, and smoke pollution from Hitachi Mining Company caused sickness. They were followed by itai-itai disease (cadmium poisoning), Minamata disease (organic mercury poisoning), Yokkaichi asthma (air pollution from petrochemical factory chimneys), and so on. Pollution in Japan was by then well known to the world as the negative side of economic growth.

Accidents and disasters caused by products have been growing in their magnitude of effects. The most prominent problem is automobile accidents. WHO announced the number of deaths caused by automobile accidents in 2013 was about 1,250,000 worldwide. The number of accumulated deaths caused by automobile accidents in Japan has reached 600,000, and the injured figure is close to 50 million. Railways and airplanes, much safer than automobiles, have also experienced their share of accidents. Once they take place, these accidents often turn into major disasters. Relatively recent ones are the 1998 Intercontinental Express (ICE) derailment (101 dead), the 2005 Japan Railway (JR) Fukuchiyama Line accident (107 dead), and so on. For airplane accidents, we have the 1977 collision of 2 Jumbo jets in Tenerife, Spain (583 dead), the 1985 Japan Airline crash (520 dead), and so on. Accidents involving ships and busses also result in large death tolls, like with the 2014 Sewol ferry disaster with victims including high school students on their school excursion (304 dead or missing) and the 2016 ski bus accident in Karuizawa (15 dead) that still have traces in our memories.

Accidents with facilities and infrastructures are also social disasters that break out while using artificial objects. They include accidents with escalators, elevators, and revolving doors, or accidents due to structural flaws in buildings. The 1995 Sampoong Department Store collapse in Seoul and the 2017 high-rise fire in London are such examples. Accidents with NPP are also facility disasters. As we saw with the 1986 Chernobyl NPP accident and the 2011 Fukushima Daiichi NPP accident, these accidents affect not just the area around it but also the entire world, and they require long-term actions against them. The ultimate disposition of radioactive waste takes tens of thousands of years, and no one can guarantee if the mankind has such capabilities (Beck 2002).

7.3.2 Overview at Major Measures Against Social Disaster

J. K. Mitchell categorizes accidents into "routine" ones and "surprising" ones. Specialists have already studied routine disasters, and principles and practices developed over the years can handle them. Surprising disasters, on the other hand, have huge effects over time and space, and without prior experience, even the specialists cannot predict them, and we need to study each one of them (Mitchell 1996).

Even for routine disasters that are easy to manage, their handling did not develop easily. People first thought that routine disasters were caused by technical problems. Their management then took improved technology and social handling. If we look at their history, however, we find that managers, reluctant to spend the cost on safety measures, often exposed workers to dangers.

Next, it was human error that caught the attention. Technical measures advanced and mechanical failures turned rare; however, with the magnitude of energy that humans control, minor mistakes caused huge disasters. The managing side had the idea that if they emphasized human error, they could avoid the cost of improving facilities and the work environment. Later studies of human factor, however, clarified that taking an error as the result, rather than the cause, and working countermeasures would better improve the safety. This finding led to implementing a countermeasure for each factor that could lead to an error, as we discussed in the former section.

Recently, organizational safety management has caught the attention. The 1986 space shuttle "Challenger" explosion and the Chernobyl NPP accident taught us that, in addition to human factor, we must also review the organization to eliminate accidents. James Reason explained that an active failure that pierces the weak points of multiple layers of defense leads to an accident with his Swiss cheese model (Reason 1997). He further named such accidents "organizational accidents" caused by organizational factors of people and technology and argued that organizational culture and management are responsible for their prevention.

As we saw above, we attribute causes of social disasters to technology, human factor, and organizations and their culture. By removing factors that lead to risk from each one of them, we have improved the technology, enhanced social regulation, implemented ways to prevent human error, and developed measures for safety management. As a result, the rate of accidents per operational quantity has drastically dropped. Erik Hollnagel, however, wrote that we would have to face and manage accidents that we cannot identify what their causes are. He argues that our measures so far are "Safety-I" and we will, in the future, need "Safety-II," that is, active safety management (Hollnagel 2014).

A typical example of applying the concept of Safety-II is the problem with Boeing 787. This model started commercial operations in 2011; however, due to its repeated damage and burn problems with batteries, it suspended operation in January of 2013. A thorough investigation has failed to identify the cause, still today; however, safety measures in case of batteries burning have been implemented, and the operation restarted in May of the same year. Some voice their anxiety that the decision does not follow the conventional Safety-I concept and the risk factor is not removed.

Ulrich Beck described in his *Risk Society* that an "industrial society at a stage where generation of wealth has turned into generation of risk" (Beck 1986). In the modern society, where what we thought were goods have turned into bads without us recognizing the change, we need to add Safety-II-type countermeasures that actively assure safety by identifying symptoms that can lead to failures and accidents through daily monitoring and managing of people or IoT like the way our computer software is continually revised.

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Chapter 8
Environmental Risks

Toshio Takatorige, Yukio Hirose, and Shingo Nagamatsu

Abstract Production and consumption pose a number of burdens on our ecological systems. The risk of causing damage to human health by environmental contamination is called, in general, environmental risk. Climate changes and infection to new pandemic influenza are believed also to be caused by the global human activities affecting global environment and ecological systems; thus, they often make part of environmental risks in the broad sense. This chapter explains each of these risks and unveils our unique methods in counter them.

Keywords Chemical substance · Climate change · Environmental risk · Global warming · Infection · Pandemic

8.1 Change in Biological System and Risk of Infection

Infections spread with the presence of (1) source (e.g., virus), (2) path of infection, and (3) susceptible host (organisms with weak immunity). History tells us that climate changes and changes in biological systems also place large effects on spread of infections.

8.1.1 Accidents with Infrastructures

Changes in nature and ecosystems have posed a number of threats to humankind. A typical example was the plague infection in medieval Europe. Global warming in recent years is causing concerns of a tropical epidemic dengue fever in Japan. This

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section will introduce the relation between changes in nature and ecosystems and risks of infection spreading through discussions on plague and dengue fever.

8.1.1.1 Spread of Plague in Medieval Europe

Plague had a history of repeated attacks in Europe. The spread in the fourteenth century, especially, killed one third of the population according to the records. Plague is an infection caused by *Yersinia pestis*. *Yersinia pestis* infects rats and rodents, and then when fleas that feed on their blood bite people, the infection is passed on. Pets like cats and dogs and livestock like pigs and sheep can carry *Yersinia pestis* as well. The devastating spread of plague in medieval Europe is explained by rodents like black rats and squirrels living in the plains of central Asia invaded into Europe for some reason. Up until the medieval, the Alps and its north were woods covered with trees. People cut down the trees and turned the land into farmland and fields to grow grass to feed livestock like pigs. The big changes in the natural and ecological systems chased out the foxes, wolves, owls, and harks out of the woods. The rodents then entered the human living environments and multiplied their numbers explosively feeding on the food residue from people. Medieval Europe had a large climate change as well causing poor crops in the cold seasons and people's nutrition worsened. Increase in people's moving among regions was also a factor in the ravage of plague. Today, plague is an infection controllable with antibiotics. It still, however, spreads locally in some countries, and about 2000 patients are reported each year.

8.1.1.2 Dengue Fever Front Moving North with Warming and Increased Risk of Infection

Dengue fever is an infection caused by dengue virus carried by mosquitos, and it is a disease local to the tropics and subtropics regions, especially Southeast Asia, South Asia, Central and South America, and the Caribbean islands. The infection has recently been reported in Africa, Australia, China, and Taiwan. The estimate is about 100 million worldwide infections annually, and about 250,000 are affected with symptoms. Mosquitos cannot live through the winter in Japan with high latitude, and dengue fever is not a resident local here. Sporadic cases in Japan, however, are increasing where the patients had been infected overseas and showed symptoms after their return (imported case). The number of patients reported annually, excluding January to March, has been 9 in 1999, 18 in 2000, and 200 in 2010. In 2014, the number of patients and infected exceeded 150 cases among those that visited Yoyogi park in Tokyo. Global warming has pushed the habitat of Asian tiger mosquitos up north close to Aomori Prefecture, and the virus may turn into a resident one. We need to keep our eyes on this risk.

8.1.2 Changes in Lifestyle and Risks of Infection

Well-known infections that change risks with the change of lifestyle include cholera, tuberculosis (TB), and AIDS.

8.1.2.1 Worldwide Spread of Cholera in the Nineteenth Century

Cholera is a disease caused by oral intake of water or food contaminated with Vibrio cholerae. Its symptoms are caused when Vibrio cholera reaches the lower part of the small intestine and produces toxin. There were seven cases of cholera pandemic in the nineteenth century. The first through the sixth pandemic originated from Bengal, India, and spread throughout the world. Economic and military activities by European countries in India and other southern Asian countries had strong influence on the spread of the disease in Europe. In the nineteenth century, the invention of steamboats gave a big boost to the capacity of transportation over the ocean. The opening of Suez Canal shortened the travel time between India and Europe, and it also contributed to more people and things traveling between the two places. At the same time, building infrastructures for health and hygiene had not caught up with the abrupt increase of population in cities like London or Paris, and the conditions were ready for the sudden spread. Cities of advanced countries like England started public control of water supply and sewage, i.e., measures for public hygiene of drinking water, food, and waste, and succeeded in terminating the spread. Other regions with insufficient hygienic environments still suffer from the spread. The 2015 WHO estimation counted 1.3 to four million cholera patients a year and 21 to 143 thousand annual deaths due to it.

8.1.2.2 Once a National Disease for Japan, Tuberculosis

Tuberculosis is an infection caused by tubercle bacillus. Tubercle bacilli are passed to human only from human. It was the number 1 cause of death in Japan during the 1900s to the 1920s when it spread throughout the country due to poor lifestyles and nutrition. The lack of systems to protect factory workers caused the nationwide spread of the disease. Under the Japanese government's promotion of the textile industry producing cotton yarns and cloth and the silk industry, a large number of young female workers lived in dormitories built adjacent to the spinning mill factories. They were far away from home and worked in day and night shifts with bad labor conditions. Poor nutrition and living environment caused sickness to some of the female workers who were laid off. They spread the tuberculosis they had caught after they returned to their home country, and the disease spread in cities and countryside all over the nation.

The government countered by setting the Factory Act to protect the factory workers and building health centers around the nation. After World War II, the government set the Labor Standards Act and the Industrial Safety and Health Act to further protect workers. The health centers organized themselves to function as central establishments for tuberculosis management and patient control. As a result, the number of tuberculosis patients has dropped in Japan who is now close to a low TB burden country. The world, however, still carries 2–3 billion tubercle bacilli patients, and in the year 2015, there were about 10.4 million new patients and about 1.4 million deaths; it is still a disease with high concerns. Recently immigrants and refugees from high tuberculosis burden countries into advanced countries with low burden increased the number of infections in advanced countries, and the situation is calling for precaution and countermeasures. In fact, major cities of New York, San Francisco, and London faced the comeback of the patient counts in the 1980s and have enhanced their countermeasures. In Japan, among the patients in their twenties, over 60% are now foreign nationals (MHLW 2016). If the number of foreign labor continues to increase, the country has to be concerned of the comeback, like European and American countries, and it has to keep tight control on tuberculosis.

8.1.2.3 HIV/AIDS Continues to Spread

In the 1980s, acquired immune deficiency syndrome, known as AIDS, entered human society, and the change of human lifestyles caused the disease to quickly spread throughout the world. When a person infected with human immunodeficiency virus (HIV) develops symptoms, the person is considered an AIDS patient. Early in Japan, AIDS started as drug toxicity where victims had blood transfusion of blood products contaminated with HIV. Recently, is it more of a sexually transmitted disease (STD) where the majority of carriers and patients are male homosexuals. AIDS is now not deadly with the birth of a drug to inhibit the growth of its virus; however, it is still an incurable infection. Since 2007, a number of new HIV infection reports have been over 1000 a year, and the reports of new AIDS patients have been over 400 annually since 2006 in Japan. This means the number of patients is steadily growing in Japan. In the world every year, about 2.1 million are newly infected and about 1.1 million die. The number of patients is over 30 million with about 17 million receiving treatment. AIDS is the biggest infection WHO is fighting now (WHO 2015).

8.1.3 Risks of Pandemic with Infection to New Influenza and Alike

In May 1980, WHO announced that a type of viral infection, smallpox, was eradicated, and it appeared that human won the battle with viral infections. Immediately after that, however, pathogen unknown before like HIV, *Escherichia coli*

(*E. coli*) that causes colon bleeding O157, and norovirus suddenly surfaced in our world. In 2003, severe acute respiratory syndrome (SARS) started in southern China and quickly spread around the whole world. A new influenza H1N1 type started in Mexico and spread to the United States and to the world. The world is alert against a revisit of the Spanish flu-like pandemic a hundred years ago from 1918 to 1919. It is estimated that this pandemic infected about half a billion people and killed over 50 million. Today, the most feared new influenza is the H5N1 type. The new flu epidemic in 2009 was luckily not H5N1 type. Wild birds and domestic poultry usually do not have symptoms even when influenza viruses infect them. Especially when highly pathogenic avian influenza H5N1 outbreaks, there is a high possibility that it transforms to a new type influenza virus that infects people. For this reason, culling of all birds in the poultry farm takes place to eliminate the viruses.

WHO revised the International Health Regulation in 2005 (WHO 2008) and required all member states to enhance their preparedness against influenza pandemics. The requirement calls for international cooperation so an outbreak of a new type influenza will not turn into a pandemic. Japan in 1998 set the Act on Infectious Diseases (the official title is "Act on Prevention of Infectious Diseases and Medical Care for Patients Suffering Infectious Diseases") and, in addition in 2012, established the "Act on Special Measures Concerning Novel Influenza Infection, etc.," and the legal system is in place to counter occurrences of influenza. The law states that once a state of emergency against novel influenza is declared, the prime minister takes the role of the response headquarter chief and requests people of Japan to refrain from going out, box office entertainment, and corporations to limit public transportation. The central and local governments have set their action plans and guidelines to protect the lives and health of the people of Japan and minimize the effects on our lives and economy in case a novel type influenza or alike breaks out.

8.2 Risks of Climate Changes and Their Countermeasures

8.2.1 Risk of Climate Changes

The modern society with mass production, consumption, and disposal places an excessive burden to the global environment and is causing serious environmental concerns of global warming, ozone layer depletion, loss of tropical rainforests, and deforestation. This section especially discusses climate changes like global warming, among these problems.

Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to evaluate climate changes, and the panel has been rigorously discussing what impact they pose on our lifestyles and societies. In its Fourth Assessment Report in 2009, IPCC projected that the average global temperature would rise by 1.1~6.4 °C (Kelvin, K). The report also claimed that, although there was some uncertainty, there was no doubt that the trend of warming will persist through our future and our societies needed to adapt to the climate changes. In the Fifth Assessment Report in

2014, Working Group II reported the following eight risks that the climate changes would pose on our lives based on the up-to-date scientific findings (IPCC 2014).

First was the risk of storm surge damage along the coastline caused by sea level rise. When warming melts glaciers and raises the sea surface temperature to cause thermal expansion of seawater, the sea level rises. This rise immediately impacts high risk of inundation along coastlines. In fact, it is estimated that if the sea level rises by 1 m around Japan, the number of people living in sub-zero areas of average tide levels will double from two million to 4.2 million. Many lowlands are protected by levees; however, sea level rises will raise the latent risk of storm surge and tsunami attacks. The rise of the sea level is said to affect the ecosystem as well. When the sea level rises, seawater invades further upstream the rivers and expands the brackish water areas. Fish and shellfish change their habitat with the change of water environment, and there is the risk that fishermen's livings will be affected.

Secondly, heavy rainfall would cause the risk of flooding damage in metropolitan areas. Higher temperature increases the amount of water vapor in the air. Global warming will increase the strength and frequency of heavy rain. The number of tropical cyclones will remain at the same level or decrease; however, the number of strong tropical cyclones is increasing, and the forecast for water damage risk is higher with warming.

Thirdly, extreme weather conditions would place the risk on infrastructures that may stop functioning. Heavy rain and earth disasters are local weather phenomena. However, if lifelines like electricity, water supply, or information networks are damaged, their stop of functions will lead to influence to socioeconomical systems over wide areas.

Fourthly, heatwaves could cause health damage to the weak living in urban areas. The synergistic effect of climate change over the entire globe and heat island phenomena elevate the possibility of extremely hot regions in urban areas. Extreme heat especially burdens low-income families, elderlies, and outdoor workers and increases their risk of death or damages from heatstroke.

Fifthly, temperature rise and droughts would pose risk on safe guarantee of food supply. Higher temperature and unstable rainfall can cause drop in agricultural production due to usual crops not adapting to the weather changes. If the price of food products goes up over the world, it will impact low-income families in their good quality food supply.

Sixthly, insufficient water supply and climate change would put the living of farmers at risk. Depletion of irrigation water and irregular weather conditions can lower the crop yield, and farmers and herders with minimum capital may have to face serious drops in their income. Natural disasters like flooding may further take away their minimum means of production like farmland, machines, and livestock, and they may suffer great damages.

Seventhly, the rise of seawater temperature could destroy the ecosystems along the coastlines. Coral reefs near tropic and subtropic coasts not only provide living space for a variety of creatures, but they also provide the function of purifying the seawater. Higher seawater temperature causes coral bleaching and in some cases death. The seawater temperature rise can cause a great amount of influence on the ecosystems near the coastlines. Oceanic creatures along the coastline are important economic resources in terms of food supply. Once the oceanic ecosystems are destroyed, there will be large damages to the fishermen living on the coasts.

Eighthly, climate changes would pose the risk of losing functions provided by the forests on land and underwater ecosystems in rivers and ponds. Forests not only provide living space for a number of animals, but they also supply oxygen and nuts. If global warming causes shifts in the forests, animals living in them will also change their habitats, and the resulting animal damages in neighboring farmlands will result in economic loss of resources for the farmers.

8.2.2 International Actions Toward Climate Change Risks

In response to the risk of environmental changes at the global level, the 21st United Nations Climate Change Conference (COP 21) was held in Paris, France, in 2015. During this conference, 196 countries and regions formally agreed to the international framework about actions against global warming to start in 2020 (Paris Agreement) (United Nations 2015). The Paris Agreement specified a target for the international society to keep the average global temperature rise to less than 2.0 K by means of taking advantage of mechanisms of the markets. It was a large forward step with all member countries, including developing countries as well as advanced countries, reaching an agreement. Even if the agreement is followed, we have to accept a temperature rise of about 2.0 K and thus need to take further counteractions against various climate change risks.

8.3 Environmental Risks and Their Countermeasures

8.3.1 Environmental Risks of Chemical Substances

The modern society is experiencing mass production and mass consumption that human never experienced throughout its history. The primary hazards of environmental risks are chemical substances intentionally produced as industrial products and chemical substances that the processes of manufacturing and disposal produced as unintended by-products. PCB and benzene are examples of the former and organic mercury, dioxin, and sulfur oxide of the latter. When these chemical substances are discharged into the air, water, or ground during production, consumption, or disposal, they contaminate the environment.

Hazardous chemical substances pose threats to our health, e.g., they can cause cancer even with minute amount in the environment if we continue to introduce them into our bodies for long periods. Minamata disease, itai-itai disease, and Yokkaichi asthma in Japan are examples of serious harms to local residents exposed to large quantities of hazardous chemical substances.

8.3.2 Higher Concerns over Environmental Risks and Changes in Countermeasures

What lifted people's concerns over environmental risks were the four major pollutions that caused serious health damages to people. Large petroleum complexes built during the post-war high economic growth period disposed hazardous chemical substances generated during production directly to the air, water, and ground without treatment and residents in the areas suffered damages to their health. The health damages caused by environmental pollution, lawsuits by the victims and their supporters, public movements, and people's higher concerns over pollution pushed for the establishment of Basic Law for Environmental Pollution Control in 1967. It was followed by Air Pollution Control Act, Water Pollution Control Law, and Waste Management and Public Cleansing Law, one after another, to promote prevention of environmental contamination.

These laws for pollution prevention set standards for factory discharges and local environment concentration of mercury, cadmium, sulfur dioxide, and other pollutants. Enforcing these countermeasures against pollution contributed to improving serious air pollution and water contamination, and people's concerns spread to other chemical substances. In her 1962 book "Silent Spring," Rachel Carson (1962) pointed out that the ecosystem of wild birds was suffering damages caused by pesticides like DDT. The book made it to a worldwide bestseller. In 1974, Sawako Ariyoshi's "Fukugo Osen" (Complex Pollution)," a newspaper series alerted the society about environmental contamination caused by multiple chemical substances. These works were followed by further publications and media coverage about the environment and people started to fear for contamination of the living environment and health damages caused by chemical substances in daily products.

The concerns spread to living conditions including water contamination in Lake Biwa in Japan due to living drainage containing synthetic detergent and dioxin production from burning plastics. Once the consumers understood that their own activities of consumption and disposal could contaminate the environment and cause health hazards, they started to turn their lifestyles to save the environment.

Serious health damages started to take place all over the world including the toxic gas leakage from a pesticide factory in Bhopal, India, in 1984. Triggered by these accidents, the United States and Netherlands acknowledged the people's rights to know the use and discharge of chemical substances and built the rules to make such lists available. Japan, in 1999, set the system Pollutant Release and Transfer Register (PRTR) for which companies producing or using hazardous chemical substances have to report the amount released to the environment to the administration.

The above history led the whole society to recognize the importance of knowing which chemical substance contains what amount of risk and the need for effective control for avoiding such risks. As a result, at the end of the twentieth century, methods for risk management were searched and developed against a number of chemical substances.

8.3.3 Managing Environmental Risks

We will next discuss effective management of environmental risks from chemical substances. In 1997, the US Presidential/Congressional Commission on Risk Assessment and Risk Management proposed a six-stage framework for risk management. The six stages involve defining the problem and putting it in context, analyzing the risks associated with the problem in context, examining options for addressing the risks, making decisions about which options to implement, taking actions to implement the decisions, and conducting an evaluation of the actions. Other countries often reference these processes in evaluating new environmental risk management methods. As methods and procedures of evaluating risks of chemical substances caught the attention, research advanced in finding a common scale for evaluating environmental risks of which chemical substances affect human health to what extents. Once the environmental risk of each chemical substance is evaluated, we can then identify risk management of which chemical substance to prioritize and to reduce the risk to what level.

The magnitude of environmental risk from a chemical substance depends on the severity of health damage when exposed to the substance (e.g., exposure to benzene can cause leukemia in which case the worst scenario is death) and the amount of intake of the substance from the environment (e.g., the lifetime intake of benzene). In general, environmental risk evaluation proceeds in checking the hazards associated with the chemical substance, analyzing the relation of volume to reaction, measuring the amount of exposure, and assessing the risk, that is, first confirming the harm to health by the chemical substance and then evaluating how high the level of harm is to the health with the amount of intake, next the process of estimation to what level people take the substance from the environment, and last, judgment what level of health damages to expect at what level of exposure.

We now explain the four-step environmental risk evaluation in Uchiyama's paper (Uchiyama 1996) with benzene. Benzene is produced from synthetic resin and other materials at the rate of about four million tons a year. Epidemiological studies of leukemia with workers in factories that use benzene as glue and animal experiments have confirmed that benzene is a carcinogenic hazardous material. The unit risk of benzene in terms of developing leukemia is the measure of the level increase in the risk of leukemia with lifetime intake of 1 microgram per 1 cubic meters. The volume-reaction relation, according to an overseas epidemiological study, estimates the unit risk of benzene at 3–7 for every 1 million persons. Measuring the benzene concentration in the air gives an estimate of exposure to benzene. If we calculate the environmental risk of benzene in Japan from its unit risk, concentration in the air, population, and average life, we can estimate the leukemia outbreak risk at several tens of people a year.

8.3.4 Problems in Environmental Risk Management of Chemical Substances

We have gradually been gaining study results of environmental risk evaluations for chemical substances hazardous to our health like benzene and dioxin. There are, however, about 100,000 chemical substances in use over the world and about 50,000 in Japan alone. Each year, the industries develop hundreds of new chemical substances, and environmental risks of most chemical substances have not been clarified at this time.

Chemical substances with scientific evaluation of their chemical risks are only a part of them all. The Act on the Evaluation of Chemical Substances and Regulation of Their Manufacture, etc. sets the rules of risk evaluation before introducing products into the market if they contain chemical substances that may cause health hazards. Chemical substances with large risk evaluation have their production banned or their use limited by this law. The fact, however, is chemical substances subject to such restrictions make only a small part with those with clear health damages by past pollution or confirmed health damages to workers in the production fields.

For most chemical substances, even without clear damages caused, their sizes of risks are not clarified. Currently, chemical substances suspected to pose large health hazards include persistent organic pollutants like dioxin, polychlorinated biphenyl (PCB), and dichlorodiphenyltrichloroethane (DDT). These substances hardly deteriorate in the natural environment; thus, they are persistent, and once discharged in the environment, they travel and diffuse to a wide area over the globe. Further, they accumulate when living organs take them into their bodies and thus are highly hazardous to ecological systems. Countries of the world have agreed to cooperate in regulating their production, like with Stockholm Convention; however, tackling the problem of their risk management at the global level is one that we just started.

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Chapter 9
War, Crimes, and Terrorism

Shingo Nagamatsu

Abstract Unlike accidents or natural disasters, war, crimes, and terrorism are all incidents caused by people's specific intentions. Nevertheless, these events, just like accidents and natural disasters, are greatly influenced by development of scientific technology and social structures of political disagreement and economic disparities. This chapter overviews structures and what are special about war, crimes, and terrorism.

Keywords Disparity · Ideology · Nation · Religion · Social isolation · Violence

9.1 War, Crimes, Terrorism, and Societal Safety Sciences

Nobody argues with the fact that war, crimes, and terrorism are threats to people's lives and properties. These problems, however, have fundamentally different nature in contrast to accidents and natural disasters we have discussed in this book so far.

Accidents and natural disasters, in general, have differences in whether they are caused by men or nature; however, they are both unintended. War, crimes, and terrorism, on the other hand, always come with an individual, group, or government that intentionally starts them. In other words, accidents and natural disasters are unintentional and unfavorable results of societal activities by humans, and in contrast, war, crimes, and terrorism are actions started by human for specific intentions or purposes. For this reason, measures for protecting the societies from war, crimes, and terrorism center around how to manage these executors or their motivations. We will discuss four approaches below:

The first approach is to eliminate motivations to start war, crimes, or terrorism. For example, one of the fundamental reasons to start terrorism or war is economic,

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religious, or ideological conflict among countries or groups involved. If we can resolve such conflicts peacefully, we can avoid the breakout of war and terrorism. Crime rates, also, are known to have high correlations with economic poverty and disparity in the societies. Thus, if we develop the economy to remove the disparity, we should be able to reduce crimes. For these approaches to make actual effects, they will take long times and enormous efforts.

Then comes the second approach as an important method to control executors of war, crimes, and terrorism. This approach removes or constrains individuals or organizations with high probabilities of planning war, crimes, or terrorisms. The 2003 US military attack against Iraq and the bombing of Syria and Afghanistan upon declaring Islamic State of Iraq and the Levant was a terror organization are typical examples of such approaches. For domestic crimes, police captures the suspect under the law. Actions against organized crimes and terror attacks include police investigation against illegal actions before the incidents.

The third approach manages results of war, crimes, and terrorism. This approach saves victims of military or terrorist attacks, controls the spread of damages, and provides care for the victims.

The fourth approach controls motivations for war, crimes, and terrorism. Arranging international rules and cooperation among international societies have continued in their efforts to raise the political price to pay for making military actions. From now on, it seems that we need approaches to socially encompass individuals that seem to turn radical and make terrorist acts and approaches to maintain environments with physical structures in cities that make it hard for crimes to take place.

Among these approaches, the third and the fourth not only reduce damages from war, terrorism, or crimes, but they can also contribute to mitigating damages from accidents or natural disasters. We will discuss the fourth approach, with similarities with countermeasures against accidents and natural disasters, in some detail.

First, we need to check the definition of war, terrorism, and crimes. Terrorism has large influence over interests of the international societies; thus, it has so many definitions that one can probably write a book on its definitions. There are, however, three points that are agreed among most studies: (1) the act has political or religious intention, (2) it targets civilians, and (3) it is a violent act. This chapter defines that terrorism meets all of these three conditions. A violent act targeting a citizen is a crime if it does not have a political or religious intention. We will not discuss nonviolent acts like a scam. As Fig. 9.1 shows, if a violent act with a political intention is not targeting civilians, it is a war which is an execution of the right of belligerency by a nation. The fact, however, is that some terrorist acts are backed by some countries blurring the borderline of war and terrorism; however, this book will not discuss this matter. Our explanation here gives a common understanding that war, crimes, and terrorism are all violent acts that individuals or groups of people make.

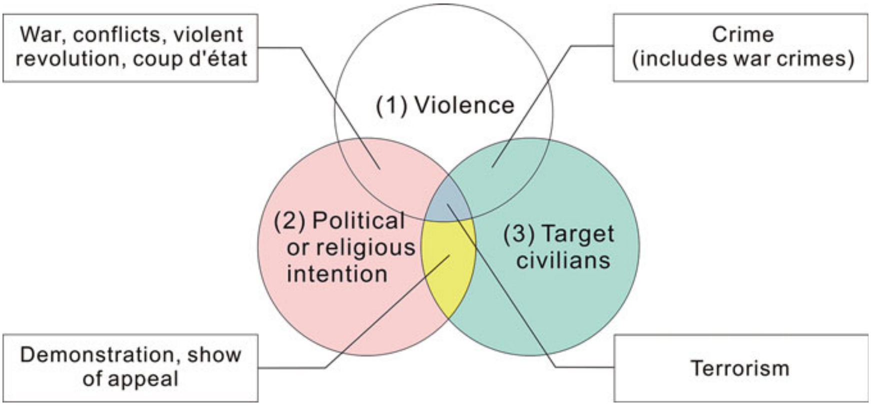

Fig. 9.1 Definition of war, terrorism, and crime, based on definition of terrorism from Ganor (2002) and Southers (2013)

9.2 War, Its Damages and Causes

First, we will review the amount of risk a war poses on our lives and properties. In the human history since the fifteenth century, the number of deaths due to war is not necessarily increasing, and Pinker explained that the number of wars is decreasing (Pinker 2013). Nevertheless, with the two world wars we experienced, the number of deaths with one war is increasing since the twentieth century. The history of Japan shows 3.2 million victims during World War II. The number is bigger by digits compared to the First Sino-Japanese War or the Russo-Japanese War. If we count the victims over the entire world, World War I resulted in 8.53 million deaths and World War II, 50 million, that is, the number of victims per each war abruptly increased.

We need to look at two factors to explain the sudden increase of victims with recent wars (Kihata 2004). The first factor is the change in how wars are fought. Up to the eighteenth century, knights and mercenaries fought wars, and the wars were between two kings. Once the countries adopted the draft systems to hire professional soldiers, wars involved the people of the countries. The two world wars in the twentieth century were typical examples, and they were battles among the full forces of the countries involved. A nation entering a full force war pours many of the economic resources into the war, and large portions of the citizens are entangled into the actions.

The second factor is the change in technologies of weapons. The advancement in scientific technology greatly increased the ability to kill with new weapons. Especially, nuclear, biological, and chemical weapons are so deadly as they have the power for human distinction. Recognizing the magnitude of devastation, a war can make now the world largely changed its concept about war. When war was a conflict between kings, it was just another method of solving the difference. The international society, however, recognized war as a "crime against peace" after experiencing World War I. The United Nations, established after World War II, enhanced the concept of group security assurance. The members, in general, view sanctions by the international society are necessary against military actions that threat the peace.

The new concept gradually reduced direct damages by war on the global basis; however, small military conflicts still take place frequently. On the other hand, the coordinated simultaneous September 11 attacks in 2001 was not a militant conflict between two countries but a new form of war between a small radical group and international peace, and this conflict is still present on our earth.

9.3 Damages from Crimes

9.3.1 World Comparison of Crimes

Murder is a typical outbreak of violent actions. Different countries have different definitions, e.g., in the United States, intentional killing is murder or voluntary manslaughter, and if the killing was unintended, involuntary manslaughter. Comparing damages from murder among different countries is, therefore, not necessarily an easy task.

The United Nations Office on Drugs and Crime (UNODC) reported that the worldwide murder victims in 2004 were 490,000. This evaluates to 7.6 for each 100,000 people. This number exceeds 20 in South America, Central America, Caribbean countries, and South Africa and, in contrast, is less than 5 in Europe, Oceanian countries, and East Asian countries (Malby 2010). Note that numbers announced by the jurisdiction are often quite different from numbers by health authorities. Hirschi wrote that people tend to take delinquent actions when the four elements of bond, "attachment," "commitment," "involvement," and "belief" are weak (Hirschi 1969).

In a recent field of study, environmental criminology explains crimes with the environment that surrounds the society. A theory in the study field, "Routine Activity Theory" explained a crime breaks out when the three conditions of "potential offender," "suitable target," and "absence of capable guardians" are met. In other words, absence of capable guardians, like police, is one factor for a crime to take place; however, the presences of an individual with the tendency to commit a crime and an individual that is an easy target are equally important factors (Cohen and Felson 1979).

9.3.2 *Trend of Crimes in Japan*

Japan is known as a fairly safe country in the world. In the old days, however, the situation was not so. Figure 9.2 shows the history of number of crimes per population of 100,000 and their clearance rates. After World War II, the number of crimes went up for a few years to reach a peak in the second half of 1950. The number of murder cases was 3.49 per population of 100,000 in 1952, a value similar to the 2008 values of 3.5 in Taiwan and 3.2 in Nepal.

As Japan entered its years of high economic growth, the number of crimes dropped; however, with the structural recession from financial crises in 1997, the number quickly went up and reached another peak in 2002. After this peak, however, the number dropped rapidly. Vicious and violent crimes showed similar changes.

The clearance rates, i.e., the ratios of cleared cases vs. identified crimes, have shown the opposite trends. If the police force is constant, the number of clearances should also be the same; thus a rise in the number of cases would drop the clearance rate. Nevertheless, the clearance rate for vicious crimes of murder, armed robbery, arson, rape, and so kept higher clearance rates over general crimes. This means more efforts are put in clearing vicious crimes.

Okada pointed out the following three reasons as major factors in the drop of clearance rate. First, people in the society have less bonds now, and the force to deter minor crimes is dropping, and small problems that were not taken as crimes before are now reported to the police to raise the number of identified crimes. Second, new types of crimes like stalking, domestic violence, and cybercrimes complicate and diversify criminal investigation, and stricter procedures for the investigation exhaust the available resources. Third, uncharged offenses are more difficult to identify (Okada 2006).

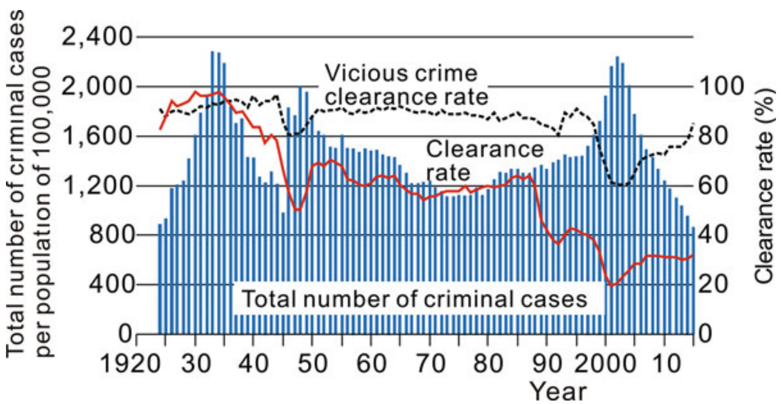

Fig. 9.2 History of number of identified crimes and their clearance rate, based on annual issues of criminal statistics (National Police Academy)

9.4 Terrorism

9.4.1 Trend of Terrorism

Terrorism has a long history, and Global Terrorism Database (GTD) records international terrorist attacks since 1970. Figure 9.3, based on this database, shows the number of terrorism incidents and deaths over the world. This figure shows us two distinct features about terrorism. The first is the fact that the number of terrorist attacks has increased since the globalization in the 1980s. Second, after the 2001 coordinated simultaneous September 11 attacks, the number of victims has also increased in the war on terror. Especially in recent years, about 40,000 are killed by terror attacks annually.

Many people think that Japan does not have terror actions; however, that is not the case from a global viewpoint. The Japanese Red Army aiming at a global revolution based on communism, for example, made a terror attack of hijacking an airplane in 1970, and the seven executors defected to North Korea. This army is also responsible for the 1972 Lod Airport massacre in Israel where they opened random fires and exploded grenades in the airport lobby killing 32 people. These actions by the Japanese Red Army were the first of international terrorist attacks and are positioned as the start of indiscriminate terror attacks (Kim 2016).

Political or religious demands should be made peacefully through political movements, speech activities, or public campaigns. At least the European and American countries, troubled by terrorist actions, grant such rights to everyone. Also, it is an undeniable fact that even if they may have similar beliefs with the terrorists, the overwhelming majority of people and groups prefer peaceful activities. An American terrorism researcher Richardson pointed out the following four fundamental reasons for terrorists to choose violent actions (Richardson 2006).

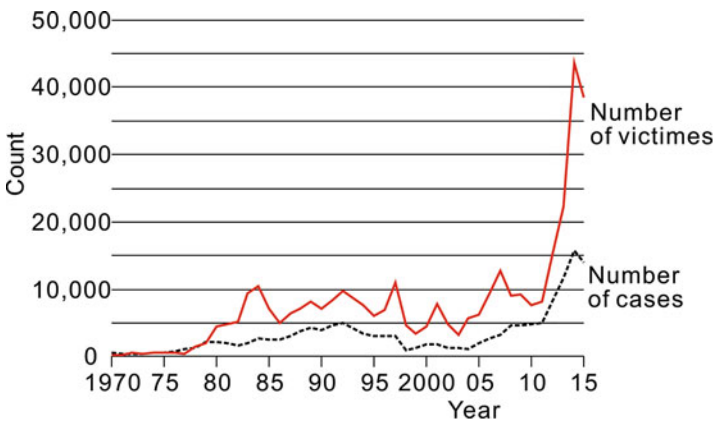

Fig. 9.3 Numbers of terrorism actions and victims, based on the data of “Global Terrorism Database”

(1) Terrorists are always minorities. People that sense they are ousted from the social structure turn to terrorism when they have the urge to make changes. (2) Emergence of a leader that explains justice to people that feel they are treated unfairly leads to terrorism. (3) Philosophies that urge people to righteousness through violence and religious or unreligious ideologies move the people toward terror actions. (4) Existence of an environment that justifies the terrorist claims.

Globalization of the societies made it possible for the minorities in each country to communicate across the borders. When their networks share ideologies of social reformation or revolution, and when the ideologies bind with ideas that justify violence, they turn into radical terrorists. One of such terrorist groups that quickly demonstrated its violence was "Aum Supreme Truth" in Japan, well known worldwide. The cult was socially alienated from the residents near its center of activity. It also fielded a large number of candidates for the House of Representatives election in 1990, however, was badly defeated. The experience gave the cult members persecution complex, and the group took on developing biological weapons as its last resort of self-defense and deterrence. The cult looked hopeless in the court case about relocating its Matsumoto branch, and in 1994 it carried out the Matsumoto Sarin attack where they spread deadly poison sarin gas toward the official residential apartment where Nagano municipal court Matsumoto branch personnel lived. The attack killed eight people. When the cult learned the police was going to start a nationwide investigation, it sprayed sarin in Kasumigaseki station in Tokyo. This was the March 1995 Tokyo Metro sarin attack that killed 12 people. Some members of the cult, to the surprise of people, had high academic records. Aum Supreme Truth had teachings that lured the intelligent with high academic accomplishments, and the leader Shoko Asahara had some charisma. Members with ample scientific knowledge made it possible to develop chemical weapons and build well-thought thorough plans for the terror attacks, trends that we see in many recent terrorist attacks.

9.4.2 Changes with Terrorism

For many advanced countries, terror attacks were mostly carried out by foreign groups. An Islamic extremist group al-Qaeda planned the 2001 coordinated simultaneous September 11 attacks to the United States that shook the whole world. The 17 perpetrators had entered the United States with visas although some were staying illegally with expired ones. Given these facts, the US terrorism control concentrated its efforts into stopping the terrorists from entering the county. One of its main concerns is to protect the nation from threats of terrorists as demonstrated with the establishment of the Department of Homeland Security (DHS).

During the past 10 years, however, the form of terrorism changed, and the above type of terrorism prevention is losing grounds. The first change is who turns into terrorists; people with the country's citizenship, who received education in the country and are working on the grounds, are turning into terrorists. They are the so-called homegrown terrorists. The second change is the frequent emergence of terrorists called lone wolves that single-handedly plan terror attacks based on information from the Internet and without organizational connections with terrorist groups. The third change is the terror targets that used to be large political events or significant facilities. Recently concerts, events, local assemblies, and restaurants with less security are turning into targets of attacks. They are called soft targets.

The December 2015 San Bernardino attack was a typical example of such changes. The target was a training and banquet event for employees of San Bernardino County Department of Public Health. Of the about 80 employees there, 14 died from random shooting. Syed Rizwan Farook, one of the perpetrators, was an employee at the department. His parents were immigrants from Pakistan but Farook, born in the United States, had American citizenship. The other perpetrator, Farook's wife Tashfeen Malik, was born in Pakistan, met Farook through the Internet, married Farook, and immigrated to the United States in 2014. The married couple had no criminal records and were not on the Terrorist Screening Database.

This type of terror attack is a big threat to local communities. The communities have to face the threat that a neighbor may 1 day turn to them as a terrorist. Bracing against these terror attacks will take, whether one likes it or not, local community involvement.

Federal, state, and county police forces will have to work with the communities as well. In this case, securing and explaining police authority is also a concern. For example, in September 2015, a 14-year-old high school student in the State of Texas, who was a Muslim, was arrested for the suspicion of being a terrorist and taken into custody. The student had put together a clock from loose parts and brought it to school. The clock resembled a bomb, and the school called in local police who arrested the student. Later the student was released without charges. An influential blogger learned about the incident through news and opened a form for people to send messages. President Obama, at the time, invited the student to Astronomy Night at White House. The student's family filed some suits but were all dismissed. This case is an indication that it is not just terrorism but also acts of terror attack prevention that can cause serious confrontation in local communities.

9.4.3 Measures for Terrorism Prevention: Case of the United Kingdom

The problem of homegrown terrorists is not just for the United States. The Canadian daily newspaper The Telegram reported that the number of foreigners that moved to Syria and Iraq to become Islamic State of Iraq and the Levant (ISIL) soldiers was about 27,000–31,000 during the years 2011–2016. Among them, about 6000 were born in European and American countries (Kirk 2016). As of July 2017, ISIL has significantly lost its power, so the number of young people that head toward Syria must have greatly dropped; however, the trend of training terrorists across borders will probably continue.

The United Kingdom has started a program Channel, since 2012, to prevent its people from being drawn into terrorism. Channel is a program to identify individuals with risks of turning radical, evaluate the risk with a checklist, and provide support to prevent the individuals from entering terror actions. At the frontline of this program are about 70,000 local teachers, public health workers, and doctors who have gone through proper training to identify individuals with the potential of turning radical. A program like Channel, seen from its outline, is a different approach from allowing public authorities, like the police, to interfere with local communities. It rather places terrorism prevention along the line of local medicine, local community service, and social education to accomplish a safe community. The approach seems even in line with local disaster prevention. Some evaluate the method highly saying it has dramatically reduced the number of young people moving out to Syria; however, some others not so highly saying the drop is simply a result of ISIL losing its power, and the program itself is not so effective. Some point out that the Channel method merely identifies individuals with risks of turning radical following a manual and that it is far apart from ideal social connotation. In either case, without doubts, the method is symptomatic and has no solution of dealing with the fundamental factor leading to terrorism, that is, minorities bearing negative feelings toward the society where they are isolated and discriminated. How to accept minorities in the society and encompassing them within appears to be public service issues; however, they are equally important in terrorism prevention. Earlier, we discussed that weaker human relations in the communities are causing increase in crimes, and the same applies to the background of terrorism.

9.4.4 Current State of Terrorism Prevention in Japan and Problems

As we discussed above, Japan has its own share of terrorism concerns. A 2013 al-Qaeda linked terror attack in Algeria, took hostages, and killed 40 including 10 Japanese. It was the reality that overseas terrorism can target Japanese. Al-Qaeda and ISIL have repeatedly announced Japan as a target for terror attacks, and people in some international terrorist organizations have been in and out of the country. With the summer Olympics coming up in 2020 in Tokyo, the threat of terrorism is going up every year in Japan.

Under these circumstances, prevention of organized crimes like terrorism must take international cooperation. The United Nations Convention against Transnational Organized Crime (TOC treaty) turned effective in 2003. This agreement clarifies that it is a crime to take part in international criminal organizations or money laundering of profits through criminal actions.

TOC treaty obligates its signees to identify and punish "agreeing to perform a serious crime" or "participating in organizational criminal group activities" as a crime separate from attempted or committed crimes. For this reason, Japan had not signed the treaty for a long time. In 2017, the Second Abe Cabinet submitted a proposal for amending the Act on Punishment of Organized Crimes to add "Crime for preparing terror attacks and alike." The proposal gave authority to the administration to punish preparations at early stages before actually committing a variety of crimes and was met with strong oppositions from minor parties and the people of Japan saying that the amendment could lead to administration going out of control. The majority party, however, forced the proposal through and enacted the bill and then later ratified the TOC treaty. Ratification of the treaty is commended for enhancing the country's prevention of terrorism; however, it also opened fundamental problems of how far we can allow the government power to expand and how we can stop the power if it goes out of control.

The more we enhance terrorism prevention, information from grassroots investigation turns more important, and there will be demands for more involvement of local communities. We are now faced with a mound of problems like if the power ends up splitting local communities, whether it will disturb human rights of people with different ideologies and foreigners, or how to avoid people excessively spying on each other. They are also problems that societal safety sciences have to look into.

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Part III
Risk Analysis and Management

Chapter 10
Methods in Risk Analysis

Eiki Yamakawa and Toshihiro Kawaguchi

Abstract To protect our lives and properties from disasters and accidents, we need to identify sources of risks, acknowledge weaknesses in our societies and ourselves, and be readily prepared in both hardware and software. We frequently express the odds of events taking place with probabilistic numbers; thus, we must have at least the minimum knowledge in mathematical statistics. This chapter first introduces quantitative evaluations of probabilities of events to cause damages to us and the magnitudes of the damages. We will then learn how to analyze and estimate risks using the evaluations. The chapter closes with decision-making methods in finding the best measures that minimize the risks.

Keywords Confidence interval · Linear model · Mathematical programming · Random variables · Relative risk

10.1 Evaluation and Probabilities of Risks

When natural disasters, like flooding or earthquakes, or accidents caused by physical or chemical phenomena take place, their formation of outbreak greatly differs with environmental factors and chances. For evaluating uncertain events like disasters or accidents, we generally apply the function called measure that maps the set of results of interest to a nonnegative real number to express its "magnitude." When we express the set for the entire results that can take place with Ω, and its subsets with E_1, E_2, the function μ that satisfies the following conditions is called the fuzzy measure.

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$$\mu(\varnothing) = 0 \quad (10.1)$$

$$\mu(\Omega) = 1 \quad (10.2)$$

$$E_1 \subseteq E_2 \Rightarrow \mu(E_1) \leq \mu(E_2). \quad (10.3)$$

The first two conditions show that when we set the size of the set of all possible results to 1, fuzzy measure is a function that expresses the ratio of the results of interest occupy. The third condition is called monotonicity, and it shows that the evaluation goes up when more results are included.

The characteristics of measures depend on how measures of unions of sets are defined. When parameter λ is a real number larger than -1, a fuzzy measure that satisfies the next condition is called λ-fuzzy measure.

$$E_1 \cap E_2 = \varnothing \Rightarrow \mu(E_1 \cup E_2) = \mu(E_1) + \mu(E_2) + \lambda\mu(E_1)\mu(E_2). \quad (10.4)$$

Probabilities that we are most familiar with are nothing but λ-fuzzy measures with $\lambda = 0$. Probabilities have complete additivity expressed with the following equation:

$$E_1 \cap E_2 = \varnothing \Rightarrow \mu(E_1 \cup E_2) = \mu(E_1) + \mu(E_2). \quad (10.5)$$

Complete additivity is a basic property to derive many characteristics about probability and is important for easily analyzing and estimating risks; however, it often conflicts with human psychology that wants to avoid uncertainty. The λ-fuzzy measure is a measure that generalizes complete additivity required to probability. In fact, when the parameter λ takes a positive number, the measure shows the property called super-additivity with the expression:

$$E_1 \cap E_2 = \varnothing \Rightarrow \mu(E_1 \cup E_2) > \mu(E_1) + \mu(E_2), \quad (10.6)$$

and the property is sub-additive when the parameter λ takes a negative value expressed:

$$E_1 \cap E_2 = \varnothing \Rightarrow \mu(E_1 \cup E_2) < \mu(E_1) + \mu(E_2). \quad (10.7)$$

In classic probability theory, when a trial results in N equally probable cases, and the number of events of interest is r, the occurrence probability of the events is defined r/N. For example, rolling a cubic die and recording the result have six possible outcomes. With a proper die, all results have equal chances; thus, the possibility of getting 1 is 1/6. The occurrence probability of an event equals the relative frequency of the event occurrence with an infinite number of independent trials. Natural phenomena, however, like flood or earthquake often break out with some events in combination, and their occurrence usually depends on past records; thus, we need to proceed carefully in applying probabilistic models to their risks.

We can easily calculate the probability of accidents of a person that flies on an airplane everyday by applying the method of “probability of the complement of an event” that we learn in high school. Setting the probability of encountering an accident with a single flight to p, and the number of flights to n, the probability of not being involved in an accident with a single flight is $1 - p$. The probability, thus, of not encountering an accident at all with n flights is $(1 - p)^n$. Subtracting this probability from the entire probability of 1, we find the probability of being involved with at least one accident is $1 - (1 - p)^n$. The frequency today of airplane accidents is about 0.3 times for each million flights; thus, if a person flies on an airplane everyday for 80 years, the probability we are looking for is:

$$1 - \left(1 - \frac{0.3}{1{,}000{,}000}\right)^{365\times 80} \approx 0.0087, \tag{10.8}$$

that is about 0.87%.

A variable that changes its values probabilistically is called a random variable, and a random variable that changes its chances with time is called a stochastic process. When the set of values that a random variable can take, like in the case of amount of rainfall or earthquake magnitude, forms a section of continuous real values. In this case, the distribution function that defines the probability that the value is less than a threshold or its derivative, the probabilistic density function, gives an idea of what the probability distribution is like. The sum of many mutually independent random variables forms a normal distribution. Normal distributions are often used to model probabilistic random phenomena like measurement errors. The probabilistic density function for a normal distribution is bilaterally symmetric around the average value. A random variable with normal distribution is most likely to take a value near the average, and the probability drops as the value shifts away from the average.

On the other hand, for stochastic processes with increasing occurrence probability with time, like for the case of machine failure, the random variable that expresses the machine life or time to failure follows the Weibull distribution. If the distribution function or the probabilistic density function is known, we can find the confidence interval about characteristic values of the average or variance without having to observe the phenomena for an infinite number of times.

Odds is a measure that we often use in comparing the likelihood of events. We can calculate the odds by dividing the number of cases that the event of interest is taking place by the number of cases it is not. If the occurrence probability of event is known, the odds for the event is the occurrence probability divided by the probability the event does not occur. For example, assume there are ten test procedures for a certain illness and A was positive with five tests, whereas B had eight positive results. A’s odds is $5/(10–5) = 1$ and B’s odds $8/(10–8) = 4$. B’s odds is 4 times that of A and the possibility of B having the illness is 4 times that of A. In general, the odds of an event of interest divided by that of a reference event is called the odds ratio. As we will discuss in the next section, the odds ratio is often used in statistically estimating the magnitude of risk for an event.

In quantitatively evaluating risk, we also need to decide how to calculate the magnitude of damage. When calculating casualty deduction for income tax filing, the following equation rationally determines the property damage from a disaster based on current value:

$$[\text{damage amount}] = ([\text{acquisition cost}] - [\text{depreciation from acquisition to damage}]) \times [\text{damage ratio}].$$

On the other hand, damage to facilities and buildings is often calculated with

$$[\text{damage amount}] = [\text{replacement cost}] \times [\text{damage ratio}],$$

because the cost for reconstruction has to enter the equation. In case of a major disaster that caused damage to transportation systems, the indirect cost of opportunity loss for being unable to use the systems sometimes enters the calculation in addition to the direct cost of reconstruction.

Among objects lost with tsunami or fires, there are things like "photo album of memories" that are difficult to give monetary evaluation, i.e., things that cause big psychological pain when lost. In case it is difficult to directly calculate the absolute value of a property, comparing the relative value to evaluations of other properties can lead to absolute values. As we can easily verify, when there are n pieces of property, $1, \ldots, n$, with values $w_1, \ldots, w_n$, the $n \times n$ matrix with (i,j)-th entry w_i/w_j has the maximum eigenvalue n, and the corresponding eigenvector is $(w_1, \ldots, w_n)^T$. Then for each pair of (i,j) from the set $i, j \in \{1, \ldots, n\}, i \neq j$, having the owner answer how many times property i is worth property j and set the answer to a_{ij}. The diagonal components of the matrix are 1, and the eigenvector corresponding to the maximum eigenvalue of this matrix is a multiple of vector $(w_1, \ldots, w_n)^T$ of absolute values of properties $1, \ldots, n$.

10.2 Analysis and Forecast Models of Risks

We can estimate occurrence probability of an independent event by counting the number of occurrences of the event of interest during a large number of trials. In fact, if the event of interest took place X times while repeating the trial N times, with a large enough N and X/N at a reasonable value, the occurrence probability p of the event of interest is within the following range with a 95% confidence level:

$$\frac{X}{N} - 1.96s \leq p \leq \frac{X}{N} + 1.96s. \tag{10.9}$$

In this equation, s is standard error expressed with the following equation:

$$s = \sqrt{\frac{X(N-X)}{N^3}} = \sqrt{\frac{\frac{X}{N}\left(1 - \frac{X}{N}\right)}{N}}. \tag{10.10}$$

In case an event of interest took place 38 times out of 380 independent trials, the 95% confidence interval for the occurrence probability is evaluated at 0.07–0.13. From the definition of standard error, quadrupling the number of trials N will halve the confidence interval for the occurrence probability p.

When the occurrence probability is extremely small, like in the case of disasters or accidents, the number of occurrences of the event of interest during a large number of repeated trials is of interest. In general, during n independent trials of an event with occurrence probability p, binominal distribution gives the probability of the event of interest to occur k times:

$$B_{n,p}(k) = {}_n\mathrm{C}^n k p^k (1-p)^{n-k} = \frac{n!}{k!(n-k)!} p^k (1-p)^{n-k}. \tag{10.11}$$

For example, if we set the probability p of getting 1 with one throw of die at $p = 1/6$, we expect to get 1 once with six throws of the die. The probability of getting 1 exactly once, however, is only $B_{6,1/6}(1) \simeq 0.402$, twice $B_{6,1/6}(2) \simeq 0.201$, and never $B_{6,1/6}(0) \simeq 0.335$.

On the other hand, when n is sufficiently large and p is sufficiently small, the Poisson distribution approximates the probability of the event of interest occurring k times at

$$P_\lambda(k) = \frac{\lambda^k}{k!} e^{-\lambda}. \tag{10.12}$$

The parameter λ is the expectation for the number of times the event of interest takes place and is calculated by $\lambda = np$. The constant e is Napier's constant, and it approximately equals 2.72. For example, with a machine that produces 1 defective product for every 500 pieces, the probability of finding at least 1 defective product in 1000 pieces produced by this machine is:

$$1 - P_{1000/500}(0) = 1 - \frac{1}{e^2} \simeq 0.865. \tag{10.13}$$

In general, there are multiple factors that cause a damage, and we often find different risk sizes for these factors. If you have two groups, one with factor A and the other without, continuous observation of the two counting the number of cases

Table 10.1 Cross table of causal correlation

		Result B		Total
		Occurred	Did not occur	
Factor A	With	a	b	l
	Without	c	d	$n-l$
Total		m	$n-m$	n

with damaging result B can lead to statistical evaluation of how factor A affects the occurrence of result B. With observation results shown in Table 10.1, the risk of result B occurring with factor A is a/l, whereas that without factor A is $c/(n-l)$; thus, the risk of facing result B when factor A is present is:

$$q = \frac{a}{l} \div \frac{c}{n-l} = \frac{a(c+d)}{c(a+b)} \tag{10.14}$$

times the risk without factor A. The value q, in general, is called relative risk or risk ratio.

When the time to see whether result B takes place or not takes too long, there are cases that the risk ratio can be estimated by comparing the number of objects with and without factor A for objects with and without result B. With the observation results in Table 10.1, the odds of factor A in the group with result B is a/c, and that for the group without result B is b/d. Thus, the odds ratio of the former to the latter is:

$$r = \frac{a}{c} \div \frac{b}{d} = \frac{ad}{bc}. \tag{10.15}$$

When the probability of occurrence of result B is extremely low, i.e., when $a \ll b,\ c \ll d$, the odds ratio r is a good approximation of risk ratio q.

When Table 10.1 is not the observation results of the entire investigation objects, but of n samples, randomly picked out from the parent population, the odds ratio is within the range:

$$\frac{ad}{bc} \div e^{1.96s} \le r \le \frac{ad}{bc} \times e^{1.96s} \tag{10.16}$$

with a probability of 95%. The symbol s is standard deviation defined with the following equation:

$$s = \sqrt{\frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \frac{1}{d}}. \tag{10.17}$$

For example, if $a = b = c = d = 460$, $e^{1.96s} \simeq 1.2$ and accurate estimation of the odds ratio will require a fairly large sample size.

When the factors that cause damaging results include quantitative data, we can analyze the risk with generalized linear model. Generalized linear model estimates the occurrence probability p of result B based on observations $x_1,\ldots,x_n$ for factors $A_1,\ldots,A_n$, with the following equation:

$$p = \frac{1}{1 + e^{-z}}, \quad z = a_1x_1 + \cdots + a_nx_n + h. \tag{10.18}$$

The calculation of determining the coefficients $a_1,\ldots,a_n$ and constant h from observations of factors $A_1,\ldots,A_n$ with result B occurrence and those without result B occurrence is called logistic regression analysis. For generalized linear models, the odds $p/(1 - p)$ of result B is e^{-z}; thus, when factor A_i increases by 1 unit, the risk of occurrence of result B is e^{-z} times in terms of odds ratio.

10.3 Decision-Making for Risk Minimization

Mathematical programming is one of the methodologies applied in rationally solving decision-making problems that we encounter in various fields of natural sciences and social sciences. Mathematical programming formulates the decision-making problem into a mathematical optimization problem to maximize or minimize the value of the objective function with variables subject to some constraints. Thus, by setting the policies for disaster management and accident prevention to decision variables, the physical and social conditions that govern the policies to constraints, and the sizes of possible risks under the policies to the objective function, we can solve the decision-making problem within the framework of mathematical programming.

When the objective function is linear and the constraints are a system of linear equations or inequalities, the optimization problem is called linear programming and is expressed in the following manner:

$$\begin{aligned} &\text{minimize} : \boldsymbol{c}^{\mathrm{T}}\boldsymbol{x} \\ &\text{subject to} : A\boldsymbol{x} = \boldsymbol{b}, \boldsymbol{x} \geq 0. \end{aligned}$$

For this set of formulae, $\boldsymbol{x}$ is the vector of decision variables, $\boldsymbol{A}$ is the parameter matrix, and $\boldsymbol{b}$ and $\boldsymbol{c}$ are parameter vectors. Setting the sizes of risks with accidents or disasters is difficult, and parameters $\boldsymbol{A}$, $\boldsymbol{b}$, and $\boldsymbol{c}$ have uncertainties. Especially when parameters $\boldsymbol{A}$ and $\boldsymbol{b}$ have uncertainties, both sides of the equation $\boldsymbol{Ax} = \boldsymbol{b}$ are uncertain; thus, it takes clarifying the constraints that require the two sides are equal for solving the linear programming problem. We then turn the problem into a "Chance Constraining Problem" that looks for the decision variables $\boldsymbol{x}$ that minimize the objective function $\boldsymbol{c}^{\mathrm{T}}\boldsymbol{x}$ under the constraints that the probability of the equation $\boldsymbol{Ax} = \boldsymbol{b}$ or its fuzzy measure is not less than a certain threshold or the "recourse problem" that adds the magnitude of the residual error $\boldsymbol{Ax} - \boldsymbol{b}$ to the objective function instead of equation $\boldsymbol{Ax} = \boldsymbol{b}$.

If the range of parameters $\boldsymbol{A}$ and $\boldsymbol{b}$ are known, the method to find decision variables $\boldsymbol{x}$ that minimize the objective function $\boldsymbol{c}^{\mathrm{T}}\boldsymbol{x}$ while the equation is satisfied whatever values $\boldsymbol{A}$ and $\boldsymbol{b}$ take is another effective approach ("robust optimization"). In assessing the effectiveness of risk management, "worst case analysis" is also well practiced that identifies the case that maximizes the objective function $\boldsymbol{c}^{\mathrm{T}}\boldsymbol{x}$ among optimized results of linear programming problems for all possible combinations of parameters $\boldsymbol{A}$ and $\boldsymbol{b}$. Worst case analysis takes solving the two-level mathematical programming problem that have the original linear programming problem in its lower level.

Chapter 11
Risk Management

Yoshinari Hayashi and Katsuyuki Kamei

Abstract Risk management consists of a series of actions to list out all possible risks, evaluate their influences, and reduce or avoid the losses. We hear the term "risk management" in a number of fields including finance, corporate management, safety of machine systems, accident prevention, and natural disasters. The fields, however, have different concepts and understanding of its controllability associated with the term. In most fields, risk is pure risk that can only produce negative effects, but in some cases, evaluating speculative risk with both negative and positive effects is important.

Keywords Pure risk · Risk assessment · Risk treatment · Speculative risk

11.1 What Is Risk Management?

11.1.1 Nature of Risk Management

Frequently quoted in other chapters, the 2009 international standards of risk management, ISO 31000:2009 "Risk Management – Principles and Guideline," defines risk as "the effect of uncertainty on objectives" and risk management as "coordinated activities to direct and control an organization with regard to risk" (ISO 2009). The concept of risk has more than one tracks of development. The first is a financial approach centered around business administration and insurance, and the second is safety engineering oriented. Further, there are the third and fourth approaches that are oriented along science of disaster management and along law. The concept of risk management is spreading among, not only corporations, but a number of fields including nation, administration, local societies, educational institutes, medical institutes, homes, and individuals.

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J. H. Fayol of France first pointed out the importance of risk management in business administration. He pointed to “security function” as a corporate activity and defined it as “protection of resources and employees” in his 1916 paper *Administration Industrielle et Générale* (Fayol 1916). Since this paper, risk management has meant management, know-how, systems, and countermeasures to overcome risk.

On the other hand, in the USA, insurance management-type risk management turned into the standard in the 1950s. The 1956 Gallagher paper “Risk Management: New Phase of Cost Control” is from that time. The paper pointed out “how much cost to spend on safety and risk management” (Gallagher 1956), an angle still in practice today. Then in the 1970s to the 1980s, American insurance management-type risk management theories made their ways into Japan.

In the 1960s, safety engineering fields in Japan started to take on risk management-type methods (Hollnagel 2014). The main reason was, at the time, machine systems quickly turned complex and they needed ways to analyze risks. For actual engineering systems, engineers developed analysis methods, for example, fault tree analysis, that estimates the probability of functional failure based on causal events and reliability data, and event tree analysis that analyzes event progress of systems.

After the outbreak of the TMI accident in the USA in 1979, methods of risk management have shown further development since the first half of the 1980s. Analyses of the TMI accident showed that human factors and human error pose serious effects on system safety. Thus, risk assessment and accident analysis started to involve people and organizations, in addition to technical and engineering aspects of machine systems, into the overall system evaluation.

Recent machine systems have complex functions intertwined with one another and, at the same time, feature distributed functions over wide areas on the Internet. The advancement of technologies in mechanical and information communication pushed for more researches in developing risk management methods, and risk management now plays a central role in resilience engineering.

Risk management originally started and developed in fields of man-made disasters; thus, its history in dealing with natural disasters is relatively new. It is difficult for human to control natural phenomena that cause natural disasters. Also, earthquakes and volcano eruptions have low frequencies of occurrence; thus, their mechanisms, needed for evaluating external force magnitudes, were not well clarified even in the 1980s. For this reason, in disaster prevention to prepare against natural disasters, it was common to set the standards to the maximum in the past records. This method only works to prevent the same disaster again and is not along the line of risk management. Risk management against natural disasters spread in Japan after the 1995 Great Hanshin-Awaji Earthquake (Okada 2004).

In case of earthquake disasters, for example, performing risk management takes damage estimation with the following procedure:

1. Establish source model for the earthquake to analyze.
2. Estimate the strength of ground motion or seismic intensity at each point of interest.

3. Estimate the magnitude of damage caused by different strengths of ground motion.
4. Collect damage estimates at locations of interest and show them on a map.

The development of geoscience theories since the 1970s and the accumulation of measurement data allowed us to reach a reasonable source model of earthquakes in item (1). Rapid advancement of theories and simulation technology of earthquake wave propagation have also made estimating spatial distribution of earthquake motion intensities in (2) based on source models in (1). A number of practical empirical equations have been proposed to relate the damage rate of buildings with earthquake movement intensities. Therefore, multiplying damage rate estimated to the number of buildings or the number of people living in specific areas gives us the magnitude of damage needed for (3). Collecting the results of (3) leads to (4) that are in fact published in the forms of hazard maps or damage estimation. Local organizations and corporation have started to prepare against disasters in risk management styles based on damage estimates from (4).

Today, what risk management means have a great variety depending on who is carrying them out against which risk and differences in the concept of management. In the field of corporate risk management, the framework of enterprise risk management (ERM) announced in 2004 by the Committee of Sponsoring Organizations of the Treadway Commission (COSO) and revised in 2016 is widely accepted (COSO 2004, 2017).

11.1.2 Concept of Risk

Risk, in the past, had been defined as "combination of the consequences of an event and the associated likelihood of occurrence" (ISO/IEC Guide 73:2002) or "combination of the probability of occurrence of harm and the severity of that harm" (ISO/IEC Guide 51:1999). ISO 31000:2009 and ISO Guide 73:2009 in 2009 added to these definitions "the effect of uncertainty on objectives." In the background of change in the definition of risk is the modern concept of risk management to deal not only with risks that cause negative effects, but also with risks with positive effect when decisions to take the risks are made.

Traditional risk management theory divides risk into pure risk and speculative risk. As Table 11.1 shows, the former is "loss only risk" like damages from natural disasters or accidents by chance. The latter, on the other hand, is loss or gain with a risk that may result in loss with changes in corporate activities or operational environment but can also lead to profit by preventing the generation of loss, i.e., the risk in case of "risk taking." Table 11.1 summarizes these risks.

Table 11.1 Pure risk and speculative risk

Pure risk: objectives of risk treatment	Loss-only risk
	Risks that only produce negative effects (loss)
	Operational risk
	Accident, disaster, liability
	Objectives related to protection, prevention, and insurance
Speculative risk: objectives of risk taking	Loss or gain risk
	Possibility of negative effect (loss) and positive effect (gain)
	Business risk, strategic risk
	Uncertainty with success or failure of new business, capital investment, new product development, funding, M&A, and so on
	Objectives of decisions about business chances and operational strategies

11.1.3 Elements of Risk

The theory of risk management mainly discusses safety management and insurance management. It takes risk as possibility of accident occurrence and covers such elements like (1) hazard, circumstances and conditions that affect accident occurrence; (2) exposure, people and objects that are exposed to risk; (3) risk, possibility of accident occurrence; (5) crisis, nearing of accident breakout and persistence of accident consequences; and (6) loss.

As we discussed in Chap. 1, the term "hazard" means latent source (generation source or characteristics) of harm. The term hazard, however, has different nuances depending on the field. Young and Tippins explained hazard as "probability of generating loss or environment and conditions that elevate the degree of loss." They also explain its synonym risk factor to mean "it is a synonym of hazard but it also includes investment risk with possibly positive outcome in addition to negative outcome" (Young and Tippins 2000). In applying risk management, we need to clarify which of these elements we place in the center of our work.

11.1.4 Process of Risk Management

ISO 31000 stands out in clarifying the term definitions and showing risk management processes that are applicable to all types of organizations. Processes of risk management takes the form of (a) communication and consultation and (b) monitoring and review interacting with each other at each stage of (1) establishing the context, (2) risk assessment, or (3) risk treatment.

11.1.5 Establishing the Context

ISO 31000 places "context establishment" at the first stage of risk management process. In establishing the context, the process defines external and internal factors to consider for managing risks and sets the applicable range and risk criteria along the risk management guideline. For the best risk management, an organization first has to recognize its context. That is to understand (1) the situations and environment where the organization stands, (2) resources the organization owns, and (3) its mission and strategies to carry out.

11.2 Risk Assessment

11.2.1 Risk Assessment

The second stage of risk management, according to ISO 31000, is "risk assessment." Risk assessment analyzes the frequency of risk outbreaks and levels of influence. At the same time, based on risk criteria, it evaluates whether to accept or avoid risks and what the significant risks are and prioritizes responses to risks. Risk criteria here are cost requirement for risk responses, upper limits of resources for risk exposures, possible benefits for accepting risks, regulatory constraints and requirements, impact on the environment, and expectations by the stakeholders. Risk assessment uses matrices and risk maps showing relations of risk frequencies and effects.

11.2.2 Risk Identification

ISO 31000 defines that the first stage of risk assessment is risk identification to find and recognize risks. Risk identification takes risk-sensitive minds to clarify the following points:

1. List out exposures, that is, to check what human and physical resources the organization has
2. Clarify what accidents may take place, i.e., human risks, physical risks, liability risks, and risks in cost
3. Find what forms of losses are expected like human loss, physical loss, non-recoverable receivable, loss of profit, or liability for damage compensation

A number of methods are available for identifying risks: (a) field investigation, (b) interview, (c) discussion sessions, (d) checklist, (e) questionnaire, and (f) flowchart.

11.2.3 Risk Analysis and Evaluation

ISO 31000 states the second stage of risk assessment is risk analysis. The third stage that follows is risk evaluation to estimate the effect of risk. In these stages, we have to assess probabilities of accident occurrences or their frequencies and the sizes of losses in case the accidents take place, i.e., the magnitude or influence of accidents. For each specific risk, the stages analyze and evaluate the probability or frequency of the risk developing into a real accident and what influence it makes as a result.

On the other hand, risk maps visualize the risks based on the results of identification and evaluation. For a risk map, a visualization for anyone to recognize the risks is important.

ISO defines risk analysis as a "process to comprehend the nature of risk and to determine the level of risk" and risk evaluation as a "process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude is acceptable or tolerable." Control self-assessment (CSA) is a method for risk analysis and evaluation.

11.3 Risk Treatment

The phrase "risk treatment" means deciding the response to risk or selecting the method of risk handling. It is a decision-making process for an organization to select the best risk handling method based on set criteria and necessary cost estimates.

Risk treatment decides how to handle the risks identified and evaluated with risk assessment. ISO 31000:2009 defines risk treatment as a process of modifying risks with possibly the following:

- Avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk
- Taking or increasing risk in order to pursue an opportunity
- Removing the risk source
- Changing the likelihood
- Changing the consequences
- Sharing the risk with another party or parties (including contracts and risk financing)
- Retaining the risk by informed decision

Risk treatment has two pillars of risk control, to prevent accidents or to take disaster responses and risk finance to prepare funds or applying insurance. There are four methods of risk treatment: (1) avoidance, (2) removal/reduction, (3) redirection/transfer/sharing, and (4) retention/acceptance. Actions to treat a risk that broke out without avoiding it involve reducing it to the extent possible. Then further efforts of transferring the residual risk to others or sharing it takes place. Parts of the risk that escaped redirecting, transferring, or sharing are kept within.

Two ways of risk retention exist: one is passive retention as a result of being unaware of it and the other is active retention with full understanding of the risk. Active risk retention is further separated into one with a priori preparation and one with no preparation, i.e., postponed response. There is advantage in active risk retention with thorough understanding of the risk over passive risk that we recognize for the first time after the exposure to it. ISO 31000 also recommends retaining risks after making decisions to do so based on information.

11.4 Executing Risk Management

11.4.1 Communication: Sharing Understanding about Risk Treatment

Figure 11.1 shows risk communication for corporate operation. The components in the figure show that companies need to share common understanding of (1) what risks the company holds and (2) how to treat such risks among (a) structures within the company and (b) outside stakeholders. Corporate disclosure of risk information means listing problems to handle, operational risks, financial standing, business performance, cash flow analysis, and corporate governance and, so in the financial report, describing "Rules and other systems for managing risks of loss" in the corporate governance report and explaining such matters in the shareholder's meetings.

11.4.2 Coordination: Organizational Structure of Risk Management

ISO 31000 defines risk management as "coordinated activities to direct and control an organization with regards to risk." Coordination in this definition means to

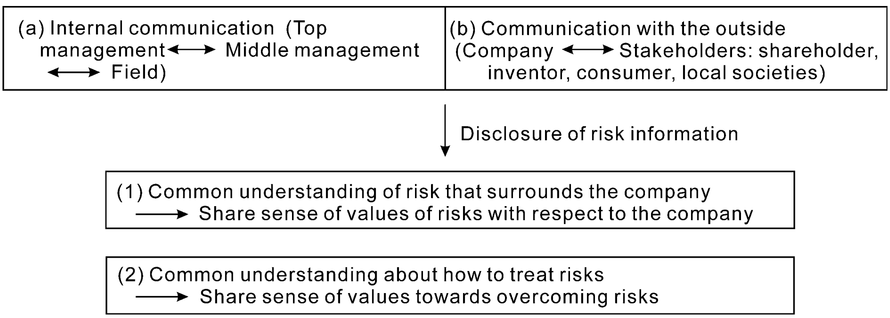

Fig. 11.1 Risk communication for corporations

organize conditions about risk treatment within the organization and to derive the best solution for interests of the stakeholders. Corporations these days commonly establish risk management committees for coordinating risk management. Risks that are unique to departments of production, sales, information processing, and so on are handled within the departments. Risk management committees take on risks that affect multiple departments or the whole companies. Today, risk treatment targets "risk optimization" by minimizing the loss and maximizing the profit. In actual societies, "risk zero" situations with no risk are impossible. Because there are risks that threaten us, we make efforts to overcome them with risk management. The efforts lead to raising corporate values.

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Chapter 12
Risk Communication and Disaster Information

Seiji Kondo, Yukio Hirose, and Hideyuki Shiroshita

Abstract This chapter explains who needs to communicate about disaster risks and how. It also discusses what the critical information are especially in response to disasters and further how to educate people in preparation against disasters.

Keywords Bidirectional communication · Disaster education · Disaster information · Reconstruction information · Risk communication

12.1 Risk Communication

12.1.1 What Is Risk Communication?

A literal interpretation of the phrase "risk communication" is to let people know information about risks. We sense risk when we face situations that can cause hazardous damage. The risk communication about exposure to radiation from the Fukushima Daiichi NPP accident (Hatamura et al. 2015; IAEA 2015), therefore, was aiming at communicating the possibilities of damage to health from radiation exposure.

What information about risk to inform people is a highly sensitive issue. For example, International Commission on Radiological Protection (ICRP) gave the information about the level of health risk from radiation exposure caused by Fukushima-1 NPP accident saying every additional 100 mSv radiation exposure throughout the lifetime adds 0.5% to the possibility of cancer-caused death. It is hard to believe that the people properly received and understood such expert information in numbers (ICRP 2007, 2011).

The risk psychologist Slovic (1987) claimed that ordinary people, instead of judging the size of risk by numeric information with probability values, evaluate

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risk with rough psychologic measures about the severity of damage and level of uncertainty in the damage to take place. If that is the case, it would have been difficult for many people to accurately understand the risk information about radiation exposure by ICRP. On the other hand, risk communication by the government through press conferences immediately after the accident repeated there were no immediate effects on the human body. People were eager to know if they could do nothing if there were no effects or even if there were no immediate effect would there be effects in the future and, if so, what preparations they should take.

12.1.2 What Information to Provide with Risk Communication

Information expected with risk communication is the size of the risk and how to respond to it. That is not only to inform the risk size to people that are about to or in the future be exposed to a risk, but also to explain how to avoid and reduce the influence on people that are being exposed to the risk.

Janis and Mann studied decision-making at times of crisis (Janis and Mann 1977) and found that people in general tend to judge that the impact of the risk is less if they cannot find effective responses to the risk or stick to actions they have been taking to the point, even when they are informed of an approaching risk. Informing only the size of a risk hampers proper reaction to it, and it is important to explain how to cope with it with risk communication. The risk communication in Sect. 12.1.1, in addition to giving information about risks with radiation to people with possible harms to their health, should have explained, for example, how to measure radiation, methods of decontamination, how to select uncontaminated food, and the need for evacuation.

Fukushima Prefecture, after the breakout of the nuclear accident, opened a window and a health consultation hotline for its residents to carry out risk communication for inquiries about radiation exposure. The residents had a variety of questions starting from the level of radiation, influence on health, possibility of food contamination, how to lead their lives, decontamination, evacuation, and so on. During the early stages, many questions were about sizes of risks from radiation exposure, but as time passed by, they were more about how to handle radiation exposure (Osawa et al. 2015).

Osawa et al. summarized the points and problems with risk communication about radiation exposure based on their experience of answering inquiries from residents at the consultation window: "Using technical terms like Sievert (Sv) or Becquerel (Bq) made it difficult to explain and have residents understand the risk of radiation exposure. At the time, even the specialists and scientists had different opinions about health hazards from low-level radiation exposure of 10 mSv or less, and it was difficult for the residents to understand the information we gave. We had to show our empathy to the residents' feelings that they hated and were scared of radioactive material or they would not listen to our explanation. Further, it was most important to find and inform what each and every resident, with different situations and circumstances, could do in leading life, managing health, and making actions."

12.1.3 Roles of the Sender and Receiver of Risk Communication

As we saw with risk communication on radiation exposure caused by the Fukushima-1 NPP accident, the senders of risk communication were engineers that developed the technology accompanied by risk, specialists of the utility company that employed the technology or administration staffs, all with proper knowledge of the risks. The purpose of risk communication, however, was not to persuade residents that the scientific technology had large advantages with small risks. The sender of risk communication had the responsibility and duty of providing necessary and sufficient information to have the residents recognize how the risk affected their health, lives, and natural environment, so they could make their own judgments about the needs for preparation and responses.

The audience, on the other hand, were citizens subject to possible exposure to risk then or in the future, i.e., those directly affected by events that caused risks. They were not there to receive one-way directions from the senders to accept scientific technology with risk or to select measures to avoid risk for themselves. People needed simple and clear knowledge about necessary cost and effectiveness of measures to avoid or lessen the impact of risks. Risk communication gives the necessary information to the people so they can judge if scientific technology can provide benefits they want and if the risks the scientific technology has are acceptable to them. The audience of risk communication has the rights to know information about risks and the responsibility to judge whether to accept the scientific technology with risk or not.

The sender and audience of risk communication have to acknowledge their own roles and, at the same time, the role of the other party of the communication. A lack of trust in the role of the other party will never reach common understanding through risk communication. The audience trust in the sender, i.e., scientists and engineers, has two facets: the trust about the skills of the sender and the trust about the sender's intention. The receiving side of risk communication by the sender cannot sincerely accept the information unless there is trust that the sender has necessary knowledge and skills to accurately explain the information in plain words and has the honest intention in the efforts to transfer the information in ways understandable to the audience.

The sending side, as well, needs trust in the citizen's intent and ability. Unless the audience has the intention to listen seriously to the information about risks and the ability to make judgments after thorough evaluation of the risk information, scientists and engineers would not spend the time and efforts in preparing information for risk communication out of their resources in scientific and engineering research.

12.1.4 Risk Communication of Societal Risk and Personal Risk

While we handle personal risks by ourselves, some risks are societal and require the whole society to take actions. Smoking cigarettes and being overweight are risks of the former type, whereas earthquakes and bird flu are of the latter. According to Morgan et al., ideal risk communication is different for personal and societal risks as follows (Morgan et al. 2002):

Risk communication for personal risks, with the assumption that the receiver citizens have limited time to pay attention, needs to help them understand the risks. It is, in fact, true that a general citizen is not an expert in specific risks and is not paying attention to risks all the time. Thus, risk communication has to allow the receivers to understand the risks in their own language and be able to cope with them for themselves.

Risk communication for societal risks need to support people having better knowledge about risks so they can judge whether to tolerate and accept the phenomenon with risk or not as a whole society. People have to reach an agreement for responding to a societal risk, thus, they have to review their own thinking and understand why their ideas are different from others in the same society. Risk communication has to offer opportunities for every citizen in the society to participate in discussions to reach a social agreement in responding to a societal risk.

Given the difference in risk communication for personal risks and societal risks, we can define risk communication as a bidirectional communication between citizens and specialists or citizens and administration for enhancing mutual understanding to reach an agreement about response to a risk.

12.2 Disaster Information

12.2.1 Importance of Disaster Information

Having disaster information is crucial for knowing how close the disaster is and making proper judgment of which regions are in need of assistance and which disaster responses can offer effective help. In our high information society with a variety of media passing global information in real time, the importance of disaster information is inevitably growing. In other words, whenever and whatever the circumstances, the quality of risk communication and attentiveness toward disaster information are always being monitored.

We have to remember that disaster information is first for the disaster victims and disaster struck areas. Disaster victims, however, are not just those victims at the time but also include disaster victims in the future. Figure 12.1 shows the three categories of disaster information for the different stages along the disaster management cycle.

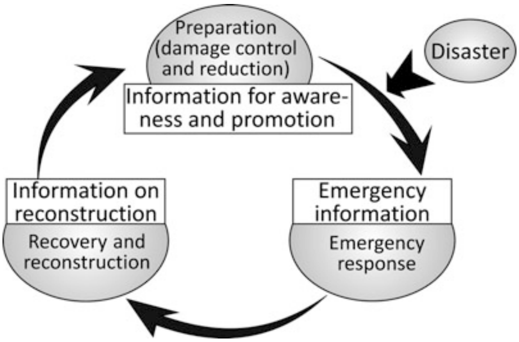

Fig. 12.1 Three types of disaster information

The cycle of three types of disaster information in Fig. 12.1, emergency information, reconstruction information, and information for awareness and promotion, is just one possible categorization for a single disaster location, and the stages do not necessarily progress in a single line in an irreversible manner. For example, emergency information and reconstruction information transferred alternatively in small cycles often mean information for awareness and promotion for disaster victims in the future.

12.2.2 Transferring Emergency Information

When hazards are about to hit, emergency information are sent out to prevent or lessen damages. Emergency information, in general, contain three elements of time, location, and size, that is, when, where, and how severe. Especially, when the hazard is almost within a reach, time information gains more emphasis, and the emergency information starts to carry the tone of a race against time.

Today with its advanced scientific technology, the Japanese society has gained new time margins by sophistication of time-related information. The Earthquake Early Warning, for example, upon detecting an earthquake occurrence, calculates the time and magnitude of strong tremors reaching regions throughout the country and sends the information out through a number of media as quickly as possible all at once. Upon receiving an earthquake early warning, systems can stop elevators at nearest floors, factory controllers can automatically stop production lines of precision machineries, and hospitals can halt surgeries before the earthquake-induced strong tremors arrive. Earthquake Early Warning is an example of an accomplished media event (cf. Sect. 3.1) that allows people to take immediate actions, based on disaster information alone, against damaging events or even before recognizing the existence of hazards.

In addition to emergency information that predicts time, location, and size of damages, a number of alerts urge people to take protective actions and evacuations. Japan Meteorological Agency sends out a large variety of information from weather warnings and advisories including emergency warnings, to weather conditions of record-breaking heavy rain in short periods. It also announces disaster management information of landslide alerts to tornado advisories, warnings and advisories of tsunami, eruption notices and warnings about active volcanoes, weather information like wind profiler (how winds are blowing at high elevations), and even information useful to our daily lives like dust and sandstorm information (MOE 2008) or ultraviolet ray indices. Local municipalities also make announcements like "evacuation orders," "evacuation advisories," and "prepare to evacuate and start evacuating elderlies."

Sophistication and, at the same time, complication of information, however, can easily lead to insufficient understanding of the information or misunderstandings. It can also end up causing troubles with people tending to wait for information or leading to serious distrust against the administration with people not tolerating failures in announcing proper alerts and making false alarms (Yamori 2013).

12.2.3 Transferring Reconstruction Information

Information about reconstruction are important for supporting disaster victims and disaster struck areas. Especially with mega-disasters over a wide area, each region has its own circumstances to follow, and continuous sending and receiving of information is particularly indispensable. The transfer of reconstruction information, however, is faced with the difficult problems of "disparity," "memory fade," and "harmful rumors," and we can hardly see any media coverage that completely meet what people are looking for.

Disparity of reconstruction information, especially, can directly lead to inequality in support. Thus, if there were differences in economic power at regions before the disaster breakout, the news coverage and amount of information sent tend to go out of balance, and the regions are stuck with the differences in economic power, or even worse, the gaps often grow bigger. For example, the amount of news coverage ranking of municipalities along the coast in Iwate Prefecture in Japan, where Disaster Relief Act applied for the 2011 Great East Japan Earthquake, remained almost unchanged. Some municipalities with small news coverage received extremely small donations even though they had suffered rather high ratio of inundation areas (Kondo 2018).

The quantity of news coverage going down with time is an unavoidable phenomenon. The coverage of the Great East Japan Earthquake dropped in the same manner for the whole and for individual regions (Kondo 2018). The small follow-up coverage failed to let the people outside of the disaster struck areas learn about post-disaster problems of lonely deaths in temporary housings or children in need of care for their mental stress. Also, even when problems of disaster capitalism are on a rise (Klein 2007), without proper coverage of the problem, people cannot reach out to provide support.

In recent years, the problem of harmful rumors is catching attention as not just the question of news coverage quantity but as its quality. Sending out the news that “harmful rumors are around” can further spread the rumors in a reproductive manner making it difficult to improve the situations. Areas struck by nuclear accidents, therefore, have the air that does not appreciate accurate news coverage of the reality. Some people displayed strong opinions about the difficulty in getting rid of, over a long time, the negative evaluation that the area is disastrous (contaminated). Some victims even showed pessimistic responses that they will just wait for the rumor to die out.

12.2.4 Information for Awareness and Promotion

One type of information effective for disaster management is detailed records of past disaster “back then” and graphic description of yet-to-come disasters “in the future.” Advancements of science and technology these days have made it possible to manipulate large volumes of information to precisely describe details of past records and portray future events. Especially in predicting the future, vast amount of calculation with the supercomputer can simulate the global climate and forecast climate changes in hundreds or even thousands of years. In addition, technologies of special effects can visualize social damages including devastating destruction in urban areas with mega-earthquakes of low frequencies and disaster preparations for events that are otherwise invisible are now possible.

Efforts are also underway in utilizing information from the past to enhance the accuracy of future prediction. Records of people’s movement in evacuating from tsunami attacks on record are subject to big data analysis in seeking important lessons and solutions for resolving the issues of chaos and stalling. Records of past disasters are effective for spreading and promoting disaster management efforts; however, we must understand the available records are in various forms. Old records are not necessarily replaced by new ones, and some old records are passed on through generations, or they are reevaluated.

Yamori pointed out that plotting medias that record past disaster information in a chart with two axes of intentional vs. unintentional and pictorial vs. linguistic gives a good overview of what they are (Yamori 2013). The categorization of whether one is intentional or not and linguistic or not is a relative measure, and there is no strict evaluation. Also, one style is not necessarily superior over the other, and all these media mutually complement one another (Fig. 12.2).

Let’s look into some records to see if they were made intentionally with efforts to pass on messages or if we happened to lay our hands on them as byproduct of disasters. Information collected by museums are usually intentionally edited and organized. TV special programs and documentary films are also created with the producers’ intentions. On the other hand, posted notices at evacuation shelters were not intended for passing on as records; however, they are important information that vividly recorded what requirements were there “back then.”

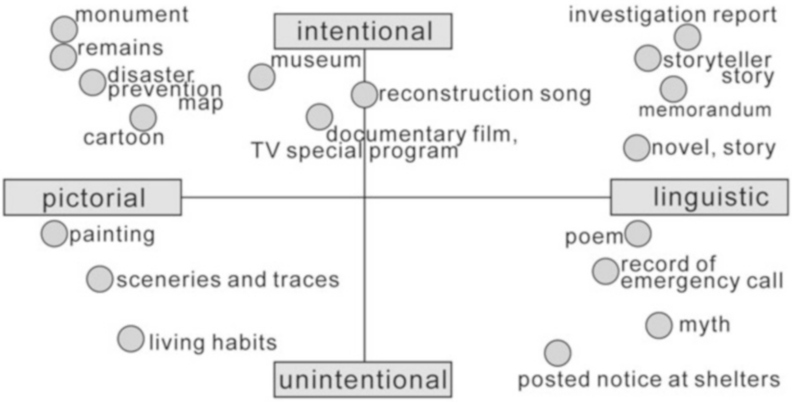

Fig. 12.2 Category of past disaster information, with some additions to Yamori (2013)

Linguistic information like memorandums, reports, and stories by storytellers are neatly arranged and easy to understand. Pictorial information, on the other hand, are easy to empathize with. In fact, paintings and remains have the power to give strong impacts on the viewers and leave messages deep within their minds. There are cases, however, that need literal explanation about why such traces of disasters were left there for the viewers to understand the situations. In other cases, stories by storytellers right in front of the remains make the information sharing effective. Another popular way of record composition gathers new photographs and remarks by visitors who were exposed to the disaster information to share on the internet or archive electronically.

Information in a variety of media can thus complement one another, and the disaster information turns more lively. There is no meaning to disaster information if they just sit there. When risk communication makes active use of them, they can have meaning for the first time.

12.3 Disaster Education

12.3.1 Transition of Concept of Learning and Disaster Education in Need

This section reviews disaster education about natural disasters for citizens including students at schools and regions since the 1995 Great Hanshin Awaji earthquake in Japan. Real efforts in disaster education started about 20 years ago, and with its short history, it still has no agreed definition. The phrase disaster education itself, however, is often talked about by people and is often understood, with the word "education" in the phrase, as something similar to school education that we are all familiar with. Because it was modeled after school education that teaches preliminarily set contents, people generally understand disaster education as an activity that teaches knowledge and skills about disaster reduction. The lack of basic knowledge and skills has been pointed out as a factor in damage widening in developing countries, and thus, teaching knowledge and skills is an important factor in disaster education. The facts in Japan, however, of low ratio of securing tall furniture to walls or reluctance in evacuation despite the immediate threat of disaster are problems not rooted in lack of knowledge or skills. Although important, teaching knowledge and skills alone does not solve problems in disaster reduction, and we need to review the way of educational activities in disaster reduction.

There are three types of learner's viewpoint about the concept of learning; (1) behaviorism learning, (2) cognitivism learning, and (3) social constructivism learning. Behaviorism and cognitivism learning focus on changes in individuals; the former means one can make an action after learning it, and the latter can recognize an object after learning about it. Social constructivism learning, on the other hand, is learning about changes in a group. It describes learning of knowledge and techniques as group sharing by its members through mutual interaction of creating and changing instead of a one-way transfer. Kariyado pointed out that current school education is based on behaviorism and cognitivism learning (Kariyado 2012). The Japanese school education system has everything to teach specified in the course of study, and understanding the contents and gaining skills to solve the quizzes are evaluated as accomplishment in education. The abovementioned disaster education is along these two styles of learning.

Disaster education, however, is different from school education because the assumption that the teacher knows everything to teach does not hold. The Great Hanshin-Awaji earthquake taught us that in disaster management, there are a number of problems with the dilemma that the right answer is not always the sole right answer. When faced with such problems, those in charge have to select what seems the best from a variety of options, and even a specialist cannot tell, "This is the right answer." At the time of the 2011 Great East Japan earthquake, a number of "unimaginable" events took place, and even experts voiced this word, for example, in "Discussions on the Current Status of Seismology" by Temporary Response Committee for the 2011 off the Pacific Coast of Tohoku Earthquake formed by the Seismological Society of Japan (SSJ 2012). In other words, we saw that experts, believed to have knowledge of the right answer, can sometimes possibly make mistakes.

Although there is no single definition of disaster education, we have to take the phrase to mean not just a one-way transfer of knowledge and skills if we want to make it meaningful. If disaster education can capture the difficulty in facing problems without a unique answer or even without any answer, interrelation of a variety of people can create, exchange, and share knowledge and skills about disaster management, and those activities make part of disaster education.

Limiting disaster management to natural disasters is general in Japan; however, that is not necessarily the case overseas. For example, in the United Kingdom, disaster education involves, in addition to natural disasters of earthquakes and typhoons, transportation accidents and fires that Japan handles as accidents (social disasters). The range of disaster management, therefore, depends on societies and times, and disasters that disaster education covers sometimes involve social disasters in addition to natural disasters.

12.3.2 Disaster Education as an Opportunity for Mutual Communication

The need for education that is not just one way, i.e., bidirectional education, is not special with disaster management and is present in fields of state-of-the-art science. In the field of science communication that deals with the relation of science and the society, it was pointed out early on that the effect of one-way education is limited, and the need to break the shell has been emphasized so far. Understanding the limitations with science, and similarly with disaster management, led to such needs. Science communication is dealing with problems that science can cast the question; however, it cannot provide the answer by itself, i.e., trans-science (Weinberg 1972).

What disaster education can learn from science communication is to acknowledge education as not just a one-way transfer of knowledge and skills but as a mutual communication. Children taking leads in evacuation drills and informing the problems they found during the evacuation to adults and specialists is an example of mutual communication. The objective of science communication, i.e., science, however, is naturally different from the objective of disaster education. If science communication and bidirectional disaster education based on social constructivism learning appear the same, that is because special interrelations in disaster reduction are taken as granted. Special interrelations in disaster management mean that humans relate to natural phenomena like earthquakes or typhoons that cause disasters through science. What this actually means is that humans scientifically explore mechanisms of natural phenomena and, with their understanding of the mechanisms, take scientific countermeasures. Basic disaster management measures in Japan have taken this interrelation as a natural assumption and have discussed uncertainties in hazard maps or climate change predictions. The method often leads to the understanding that uncertainties with individual scientific countermeasures alone are the risks. In reality, however, we are selecting scientific means from a variety of ways to deal with natural phenomena (disaster management measures) – for example, understanding them as punishment by supernatural beings like the god or taking them as mere cyclic events – and our selection of the relation itself has a risk. This viewpoint reveals that the commonly accepted disaster management measures in Japan have double risks. With science communication, the objective of communication itself is science, thus, communication about science itself is possible.

Communication with bidirectional disaster education, however, has to relate not only humans to science but also humans to natural disasters. In other words, disaster management involves a number of methods for building relations among humans and natural disasters, and whether to select scientific measures for building the relations is a point to include in the process of disaster education. Like in the case of the Nile basin before Aswan High Dam was built, a natural phenomenon that seemed to people, relating to the nature only through science, as flooding was not necessarily understood as flooding.

In bidirectional disaster education, we shall not assume that relating human to natural phenomena through science is a condition, and we need processes to think how we shall build relations with natural phenomena of earthquakes and typhoons, in other words, what we shall consider as disasters.

12.3.3 Importance of Sharing the Meaning of Disaster Management

What is important in disaster education is to recognize the problem in trying to solve issues in disaster management within the existing common framework. We have to, of course, acknowledge that disaster education is not a one-way transfer of knowledge and skills and, in addition, the reason that it is not so is not just the results of uncertainties always present with science. The uncertainties with science turn into a problem when we choose to use science as the method of disaster management, because uncertainty exists at the time of making the choice. Disaster education requires mutual communication about these two layers of risk.

For this type of disaster education, we need to set the purpose of disaster management, that is, to think what the disasters that we want to prevent are. Then we need to think how we should cope with each disaster, and if we judge that we need to take scientific measures, we shall choose a countermeasure. These processes are part of disaster education, and we need citizen participation in the selection phase. Note that the selected countermeasure has uncertainty in itself. And if the selected countermeasure is scientific, we need to evaluate the uncertainty of science in the measure. Disaster education is to build, share, and be prepared against disasters through processes of making selections with a variety of related parties about what disasters are and what it means to reduce them. Transferring knowledges and skills of how-to in case of earthquakes is just a small part of disaster education.

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Chapter 13
Crisis Management

Katsuyuki Kamei

Abstract The word "crisis" means the turning point of whether one recovers from illness or the situation worsens; thus, we can map crises into four stages of illness, i.e., "prodromal crisis stage," "acute crisis stage," "chronic crisis stage," and "crisis resolution stage." From the societal safety sciences viewpoint, crisis management means a situation where an event that threatens safety and security of the society is close or proper responses at each stage after the event have taken place. For nations, administrations, and corporations, crisis management is the "processes of responding to serious situations of major accidents or mega disasters that have suddenly broken out after some symptoms and calming the seriousness to settle and situations to recover."

Keywords Crisis · Crisis management · Crisis matrix · ICS

13.1 What Is Crisis Management?

13.1.1 Meaning of Crisis

Webster, one of the well-known dictionaries in the USA, defines "crisis" as the turning point of whether a disease is going to heal or to worsen. In other words, crisis is the time when a moderate disease condition is making a big change.

The origin of the word crisis is the Greek "Krisis (judgment)" or "Krinein (decision, make selection)." The word has a meaning of a turning point for better or worse, a decisive moment, or crucial time. The word crisis with its origin in medicine was introduced into psychology and psychiatry and started to carry the meaning of "important point" and then generalized into a term for critical danger.

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Since the word has its origin in the medical field, we can describe the four stages of crisis as Steven Fink (1986) explained as follows:

1. Prodromal crisis stage
2. Acute crisis stage
3. Chronic crisis stage
4. Crisis resolution stage

When recovery is not made from a crisis, there are cases the situation turns into bankruptcy for a corporation, death for human, and “terminal stage” in medical terms. Avoiding the terminal stage and entering the recovery stage, that is, to prevent organizational corruption or human death at times of accidents or disasters is crisis management, and it is the purpose of societal safety sciences.

“Kiki,” the Japanese word for crisis, means “Time or case when a serious trouble may take place. Dangerous situation,” and “Kiki kanri” in Japanese, the phrase for crisis management, means “Policy or organization to counter a sudden large-scale disaster, accident, or event that was unexpected. Quick and effective measures like lifesaving or prevention of damage spreading take place.”

From the above, we can say the concept of crisis is a transition of how the situation progress from a serious turning point (Delbecque and de Saint Rapt 2016).

13.1.2 Significance of Crisis Management

From a viewpoint of societal safety sciences, crisis management means to deal with a situation that an event that threatens the safety and security of the society is about to take place or to manage the state after one has happened. Koichi Oizumi, through researcher’s eyes, defined crisis management as “Predict and prevent dangers that can break out anytime and at anyplace in unexpected forms and if they take place, quickly counter them with ‘initial actions’ to minimize the damages” (Oizumi et al. 2015). Steven B. Fink defined “Crisis management, i.e., plans against the turning point crisis, are the techniques to remove many of the risks and uncertainties to control own destiny to the extent possible” (Fink 1986).

The above discussions lead to our definition of crisis management; after a “premonition,” when a major accident or disaster “suddenly” breaks out, it is the transitional process from the “serious situation” to reach a “calming” status and “recovery.”

13.1.3 Relation Between Risk Management and Crisis Management

There is subtle difference between risk management that originated from insurance management and safety engineering and crisis management that started from nation level crises like the 1962 Cuban missile crisis. Risk management features before-the-event measures like accident prevention or insurance subscription. Crisis management, on the other hand, characterizes countermeasures against emergencies after an accident or disaster.

The summary of risk management as prior measures is the following six points:

1. Listing up the risks with keen risk sensitivity
2. Identifying risks and carrying out risk assessment of analysis and evaluation
3. Determining measures against risks
4. Setting safety management plans and business continuity plans (BCP)
5. Executing simulated trainings
6. Performing risk communication

The summarizing points of crisis management with emphasis on post event actions are:

1. Recognizing premonitions with risk sensitivity
2. Having decisiveness, leadership, and good communication when suddenly put under serious situations after major accidents or disasters
3. Executing resilience after turmoil in steady situations
4. In the recovering stage, reflecting lessons learned from the accident or disaster into the action plans for the next emergencies

13.1.4 Fink's Crisis Management Theory

At the time the TMI accident in the USA, Fink was a member of the Pennsylvania crisis management team and published *Crisis Management* in 1986. The book was the first in the USA about crisis management, and it is still in print. In the book, Fink explained steps in crisis management as follows: in the premonition stage, carry out "crisis forecasting," "crisis intervention," and "crisis management plans." During the first acute stage, when a major accident or disaster has broken out, conduct "crisis survey and crisis identification." In the second acute stage, execute "crisis isolation and crisis management." Throughout the acute stages, "crisis communication" is important. Crisis communication are divided into "controlling the message" and "handling hostile press" (Fink 1986).

Among these steps, Fink introduced his unique assessment method for crisis forecasting in the premonition stage. The method evaluated a crisis with the damage and an indicator called "crisis impact value (CIV)." CIV evaluates a crisis with its effect, results, monetary loss, and damage to human, with a number from 0 to 10. The indicator is the average of the scores (0–10) to the following five questions:

Question 1: Might the crisis intensify and if so, how fast?
Question 2: How observable is the crisis by outsiders such as media, regulatory agencies, or customers?
Question 3: How much does it interfere with operations?

Question 4: Is the company the victim or culprit of this crisis?
Question 5: How damaging is it to the bottom line (however one defines bottom line)?

Fink explained the risk forecasting with a coordinate plane divided into four quadrants with probability of occurrence in the horizontal axis from 0% to 100% and CIV in the vertical axis with values 0–10. The intersection of the horizontal and vertical axes is where the occurrence probability is 50% with CIV 5. Fink named the quadrants with high probability and high CIV the red zone (dangerous area), low probability and high CIV the yellow zone (caution area), high probability but low CIV the gray zone (intermediate area), and low probability with low CIV the green zone (safety area). Fink's method was visual and easy to understand, and it has now developed into "risk map" in wide use.

13.2 Crisis Management of the Administration

Crisis management developed around national emergency situations and large-scale accidents and disasters. It, thus, has an important position in administration by the national government and so.

13.2.1 Origin of Crisis Management: Cuban Missile Crisis

While post World War II insurance management by private companies in the USA shaped risk management, the government established the concept of crisis management as a method of countering emergency situations starting from the 1962 Cuban missile crisis.

Cuban missile crisis was triggered when the USA demanded the Soviet Union back then (Soviet) to remove the midrange nuclear missiles Soviet had deployed in Cuba. At the time, the USA and Soviet were in a strong military conflict, and the risk of a nuclear war was at its peak. On 16 October 1962, a US reconnaissance plane spotted a nuclear missile deployed in Cuba. A number of discussions were made on whether to bomb Cuba or not, and on 24 October, the USA started a blockade and boarding of ships headed for Cuba. On 27 October, a US U-2 reconnaissance plane was shot down by Soviet expeditionary force in Cuba. The warning issued by President Kennedy of the USA lifted up the confrontation level, and the entire world was at a risk of nuclear war. The Soviet leader Khrushchev announced on 29 October, in reply to Kennedy's final warning, that the missiles will be removed from Cuba. President Kennedy's leadership, firm determination, and quick action added with the First Secretary Khrushchev's decision at the critical moment prevented the nuclear war.

Even during such a national emergency, the four stages apply the “prodromal stage,” cold war; “acute stage,” discovery of missile site construction; “chronic stage,” USA and Soviet confrontation; and “resolution stage,” winding down with decisions by the two leaders.

During the 1970s the world experienced national emergencies of currency crisis and oil crisis. In 1979, the TMI accident in the USA broke out. Also 1984 was the year when the Union Carbide had a gas leakage accident in its Bhopal factory in India. Occurrences of such large-scale accidents at the corporate level led to people watching corporate crisis management as well.

13.2.2 Crisis Management by the Japanese Government

We will next overview crisis management by administration and the government in Japan. Japan, in the 1970s, experienced currency crisis, oil crisis, terror attacks, and hijacks by the extremists and started to discuss the need for crisis management at the Cabinet level in the early 1980s. A Korean Airlines flight was shot down in 1983, the Glico-Morinaga case took place in 1984, and in 1990 the Gulf War started. After the burst of bubble economy, the Tokyo subway was attacked with sarin in 1995, and the concept and phrase crisis management spread to the public. Also in the field of natural disasters, the 1995 Great Hanshin Awaji earthquake triggered strong awareness of crisis management against large-scale natural disasters.

Under these circumstances, the Cabinet Law was amended in April of 1998, and the Japanese government formally made its system of crisis management. The amendment of the Cabinet Law added Article 15 that defined crisis management as “response to an emergency that has caused, or is likely to cause, material damage to the lives, persons or property of citizens, or the prevention of occurrence of such emergencies” (The Cabinet Law 1998; Yasuda 2006). The amendment newly gave the secretary for crisis management the duty of, upon occurrence of an emergency situation, making the first decision about necessary actions by the Cabinet and arranging with related ministries and agents about initial actions. In January of 2001, the Cabinet National Security and Crisis Management Office were closed, and one of the three Assistant Chief Cabinet Secretaries was assigned to take charge of national security and crisis management. The Assistant Chief Cabinet Secretary (in charge of national security and crisis management) is supported by over 100 staff members like Deputy Director General of Crisis Management, Deputy Director General of the Cabinet, and Councilor of the Cabinet. The system adds staff from ministries and agents on temporary transfer for support.

Figure 13.1 shows the flow of initial actions upon breakout of emergency situations. Once the Cabinet Information Collection Center collects information from private information organizations like the media, public organizations, and related ministries and agencies, the first notification is sent to (A.) Prime Minister, Chief Cabinet Secretary, Assistant Chief Cabinet Secretary; (B.) Secretary for Crisis Management, Assistant Chief Cabinet Secretary (in charge of national security and

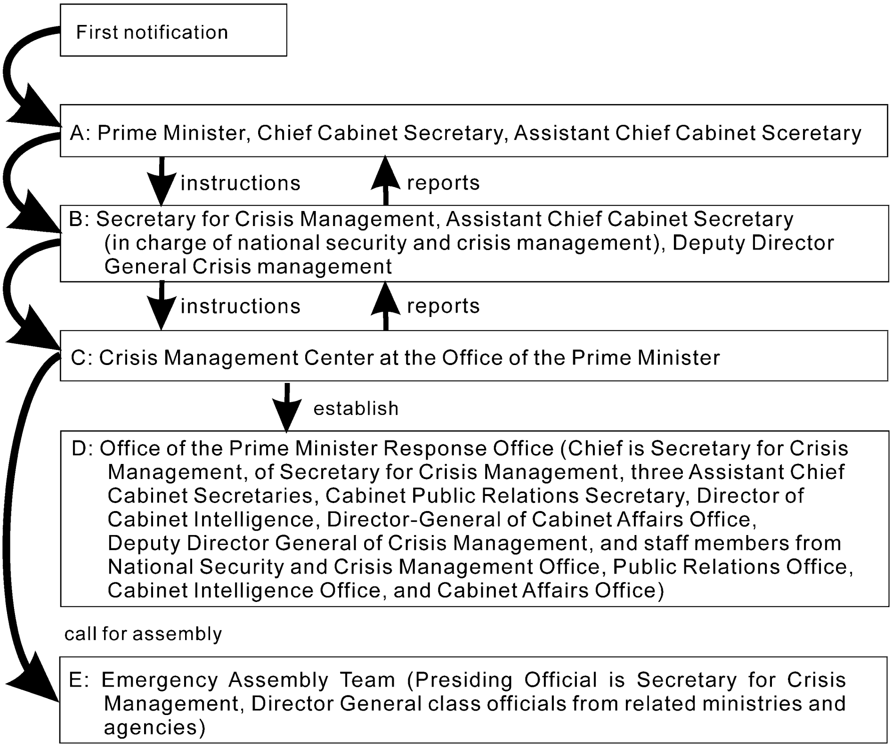

Fig. 13.1 Initial response upon emergency outbreak by the Japanese government

crisis management), Deputy Director General of Crisis Management; and (C.) Crisis Management Center at the Office of the Prime Minister. A gives instructions to B and B to C. B reports to A and C to B. C establishes D, Office of the Prime Minister Response Office (Chief is Secretary for Crisis Management), and makes calls to gather E, Emergency Assembly Team (Presiding Official is Secretary for Crisis Management). D consists of Secretary for Crisis Management, three Assistant Chief Cabinet Secretaries, Cabinet Public Relations Secretary, Director of Cabinet Intelligence, Director General of Cabinet Affairs Office, Deputy Director General of Crisis Management, and staff members from National Security and Crisis Management Office, Public Relations Office, Cabinet Intelligence Office, and Cabinet Affairs Office. This organization is in charge of collecting information, reporting to the Prime Minister, arranging communications among related ministries and agencies, and overall arrangement of initial actions by the government. E calls an emergency assembly of already listed Director General class officials from related ministries and agencies to the Office of the Prime Minister and gathers information about initial actions by the government (Kato and Ota 2010).

The Japanese government modeled its crisis management system after the Incident Command System (ICS) in Europe and the US disaster crisis management by the administration has important factors of (1) organization, (2) information, (3) evacuation, (4) self and mutual support, (5) incidence reduction, and (6) reconstruction. Especially about information, disaster information that reports what has happened and disaster management information about what to do to lessen the damage are the keys. Leadership is important for crisis management by the administration, and since quick decisions are needed, leaders have to prepare to make decisions even with insufficient information. As regulated in the Disaster Countermeasures Basic Act, when disasters break out in prefectures, the prefectural governor takes the leader role of the Head of Local Disaster Management Headquarter for crisis management. When the incident turns into a mega-disaster, the national government supports the prefectures by establishing the Major Disaster Management Headquarter headed by the Ministers of State and the Extreme Disaster Management Headquarters headed by the Prime Minister. Upon an emergency situation of a mega-disaster, the Cabinet Crisis Management Center in the basement of the Prime Minister's Office carries out the initial action of information gathering and analysis, and a team is assembled around the Deputy Chief Cabinet Secretary for Crisis Management. When the time shifts to the phase of recovery and reconstruction, the Cabinet Office then makes actions (Kawata 2008).

13.2.3 USA that Learned Its Lesson: Summary of Disaster Crisis Management

It has been pointed out that the Japanese government lacks leadership and unification of information compared to Europe and the USA. This section discusses the disaster crisis management by the role model of the US government. The 2005 hurricane Katrina left huge damages to the USA, and from the lessons learned then, the USA reviewed its disaster crisis management. Especially by thorough review of the failures during the "prodromal" and "acute" stages after things settled in the "chronic" and "resolution" stages, the USA prepared itself for the next strike by modifying the forecasting system for the "prodromal" stage and the decision-making and communication systems in the "acute" stage (POGO 2006). As a result, good effects surfaced here and there, when hurricane Sandy hit the country.

In the following seven lessons, Yoshiaki Kawata (2013) summarized what the federal government of the USA learned from failures in its response to hurricane Katrina and what improvements it implemented.

Lesson 1: From the stage when a major disaster was possible, the leader of administration carried out risk communication that warned residents and disaster prevention organizations to prepare for a disaster and make measures along disaster response programs (timeline). This action had certain effects.

Lesson 2: In the USA, federal organizations like the Federal Emergency Management Agency (FEMA) with specialized engineers and the US Army Corps of Engineers (USACE) responded to disasters in the field. The federal government gave these organizations the authorities of execution and the budget responsibilities to establish systems that could make proper disaster emergency responses based on quick decision-making.

Lesson 3: The verification system thoroughly studied lessons and failures in past disasters and did not hold individuals responsible for failures in disaster responses. The system turned the failures to knowledge and worked them into disaster response programs. The Executive Office of the President, the House of Representatives, the Congress, FEMA, and USACE independently carried out After Action Review (AAR). The system stored lessons from failures as systematic "knowledge" for the organization, so it was useful for future disaster response plans (timeline).

Lesson 4: Prepare against disasters never experienced before, and verify that lessons and failures of disaster responses are useful for future disaster response.

Lesson 5: Build structures at normal time, so when a disaster is about to strike or has struck, the head of administration can take leads and consult with specialists.

Lesson 6: Discuss measures to protect lives and economic foundations of residents in metropolitan areas with the assumption that disasters at all sizes can strike.

Lesson 7: Enhance resilience, that is, ability to recover, throughout the societies in preparation for the risks, dangers, or difficulties that threaten safety hit.

13.3 Crisis Management of Corporations

Corporate crisis management means corporations to respond properly to sudden changes in external environment, breakout of emergencies, major accidents, or natural disasters. In fact, events like terrorism, war, nuclear plant accidents, earthquakes, volcano eruptions, and tsunami are exemptions with regular insurance policies, i.e., premiums will not be paid against those events. These events, therefore, are not topics of risk management that started from insurance management, but they are topics for crisis management. Corporate crisis management differs from that of administration or a nation because if something goes wrong with it, in the worst case, it can lead to bankruptcy and the organization may disappear.

A number of studies have been made about corporate crisis management:

1. Leadership theory about how a leader makes decisions upon breakout of crisis
2. Theory of organizational crisis management that hypothesizes a crisis outbreak and discusses how to build an organization that responds to it and functions at difficult times
3. Crisis information theory to collect and properly spread information when a crisis is about to strike or has struck
4. Theory of crisis communication for both stakeholders outside the corporation and members within, about how to communicate what the crisis is about, and how to cope with it in the future
5. Theory of finance in relation to crisis management that avoids bankruptcy and balances cost and effect of crisis management

6. Study of failure that identifies lessons from major accidents and disasters and learns from failure in crisis management

Fink (1986) and Tedlow (2010) talked about the 1982 Tylenol incident as an example of best practice in crisis management. The event started with someone lacing poison in Johnson & Johnson's prime product painkiller Tylenol and killed seven people. In the "prodromal" stage, the top management upon receiving inquiry from the media took immediate actions without hesitation. They rushed in a helicopter to inspect the manufacturing factory, set crisis management headquarters, gathered all collectible information from the field, and set the fundamental guideline of "how to protect the consumers and how to protect the product."

Tedlow wrote that corporations fall into crisis when the head of operations hides inconvenient facts. In case of Johnson & Johnson, the company sincerely faced the facts without denying the inconvenience that poison was mixed in their product (Tedlow 2010). Actions by the top management was appropriate when the incident took a sharp turn in the "acute" stage.

Johnson & Johnson's corporate policy "Our Credo" lists it responsibility to the customers, employees, local communities, and shareholders. The top management placed the highest priority on social responsibility of the corporation and under the policy of "for the citizen's reliance, speak all that is known and immediately speak new information," carried out crisis communication to all stakeholders outside the company.

In the "chronic" state when things started to settle, communication inside the company also received attention. Top management wrote a letter to all employees explaining how they reacted to the crisis and what they intended to do. After the turmoil settled in the "resolution" stage, the social reputation of the company went up with its sincere crisis management despite seven deaths and additional cost of 100 million US dollars.

The framework of crisis management starting from the "prodromal" stage, then the "turning point" of an outbreak of a major accident or disaster, and then making transition through "acute," "chronic," and "resolution" stages also applies to nations, administration, and corporations. This chapter overviewed crisis management with nations, administration, and corporations, and the methodology is, of course, also applicable to individuals. Today, expressions and ideas of special incidences and crisis management for the living are widely spread.

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Part IV
Social Mechanisms for Disaster Management

Chapter 14
Public Systems for Disaster Management

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Abstract In a law-abiding nation, the law plays a big role in maintaining social peace and people's safety. This chapter overviews the document system of laws and guidelines and roles of administrative organizations and corporations.

Keywords Design standards · Standardization · Watchman state · Welfare state

14.1 Societal Safety and Legal System

14.1.1 What Is Law? System of Law

Japan has a system of various laws with the Constitution at the top. Legal regulations that the National Diet set include the Civil Code that regulates relations among private individuals, the Penal Code that is the substantive law about crimes and penal, the Administrative Code that is the positive law about actions of administrative rights and corporations, and so on. Details of laws are often regulated by Cabinet Orders by the Cabinet Office and Ministerial Orders by each ministry. Cabinet Orders and Ministerial Orders are often collectively called governmental and ministerial ordinance. Governmental and ministerial ordinances can be issued by the administration without discussions in the Diet, and since they are commissioned by the law, they have legal bindings. In addition to orders, administrative organizations can issue notices, manuals, guidelines, and alike, but they are not legally binding. On the other hand, local governments can issue municipal ordinances based on Local Autonomy Act, as long as they do not violate laws and orders of the nation.

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Administrative organizations enforce ex ante regulations for securing safety of products, services, facilities, and so on. For example, Article 1 of the Travel Agency Act requires registration of travel agencies to "secure safety of travel." Article 1 of the Electricity Business Act sets its purpose to "assure public safety and promote environmental preservation." Administrative entities supply the details like the safety standards through governmental and ministerial ordinances that are commissioned by these acts. Ex ante regulation in most cases is arranged through licensing systems for the business entities. Recent interpretation, however, with the exception of special fields like nuclear power safety, by comparing citizen's rights and public welfare, is "Minimum set of regulations appropriate for countering risks should be enforced" (Furuta and Nagasaki 2016). In the complex modern society, ex ante regulation means direct rise of administrative cost. So, in recent years, ex ante regulations are relaxed to the extent possible, and the idea is to provide means of ex post rescues in the form of litigation in case of conflicts. Relaxation of ex ante regulations allowed corporations to carry out businesses in a freer manner than before; however, they must prepare systems to prevent affairs and accidents beforehand so they can prove they had prepared reasonable prevention measures in case of lawsuits.

14.1.2 Corporations and Societal Safety

Corporations that provide goods and services around us have heavy responsibilities about keeping our societies safe and secure. Corporations have to prevent product malfunctions and accidents by employees' errors. Companies that produce goods and hire employees have a number of legal liabilities about safety management.

Recently, with the ex post rescue system, laws have been enforced to require companies to build autonomous safety management systems. The Companies Act enacted in 2005 states that the director has to construct an internal controls system and commissioned the Ministry of Justice Order (Ordinance for Enforcement of the Companies Act) enacted in 2006 to set the details. The ordinance imposes the duty to corporate groups to build "a system to regulate the management of risks of loss" across the entire group, i.e., a risk management system (Article 100, Paragraph 1, Items 2 and 5).

The level of risk management systems required with Companies Act is, according to judicial precedents, "A management system that fits the size and characteristics of the business" or "an adequate risk management system that were deemed standard (at the time it was built)." The judicial precedents show the contents of risk management systems are within the discretion of the executives (Daiwa Bank Shareholder Case, Osaka District Court, 20 Sept. 2000; Yakult Honsha Shareholder Case, Tokyo District Court, 16 Dec. 2004). "Manuals" and "guidelines" by the administration work as standards at the time provide incentives for companies to refer and follow them.

Laws that hold the director of businesses responsible after breakouts of disasters or accidents are the negligence of management and supervision in Punishment for Causing Death or Injury through Negligence in the Pursuit of Social Activities (Penal Code Article 211). This punishment applies to the direct offender; however, according to judicial precedents, while the death or injury could have been prevented, when the director or supervisor neglected “management or supervision” of the direct offender, ruling of violence of duty of care has been made depending on the degree of malicious intent. This is probably because by holding the director of the facility or the company in case of a large facility fire or product accident, the Penal Code is expecting corporations to polish up their safety management system. The conditional requirement foreseeability, however, needs “actual concern”; thus, it is difficult to say that the director or supervisor, who is not the direct offender, has foreseeability. The ruling with Morinaga Milk arsenic poisoning incident adopted the vague anxiety “feel of concern” for foreseeability (Takamatsu High Court Ruling 31 Mar. 1966); however, it is no longer supported.

14.1.3 Central and Local Governments and Societal Safety

The central and local governments have the first mission of maintaining and securing societal safety. They put a number of administrative methods in practice to accomplish the requirement: supervision and regulation; benefit, support, and compensation payments; administrative legislation; administrative planning; administrative guidance; administrative contracting; information gathering; management; provision; administration enforcement and penal punishment; building and operating facilities; and so on. Many of these practices are based on regulations and ordinances, and the congress and councils control the administration with laws, i.e., the “principle of law (ordinance) based administration” is in effect. The laws and ordinances spell out the concepts of administrative practices by the nation, prefecture, and municipalities for maintaining and securing societal safety. We can even say that the laws and ordinances describe how societal safety is secured and maintained.

Traditionally, the central and local governments put efforts in maintenance and securing of societal safety by prohibiting businesses and actions that pose threats to societal safety and licensing systems to allow the operation under some conditions or applications. Most activities by corporations require approval or licenses, and the governments and corporations are in regulator and regulated relations, but we can say they cooperate in keeping and securing societal safety. The Administrative Procedure Act (2005) states to set the review standards (Article 5), make efforts to set standard processing time (Article 6), ban return or denial of flawless applications (Article 7), post the reason in case of denying an application (Article 8), provide information necessary for application and the review progress (Article 9), and make efforts to organize public hearings if interest of people other than the applicants needs consideration (Article 10).

Taking public health, for example, the Community Health Act states to build prefectural health centers and municipality health centers, set basic guidelines for local health measures, and build plans for supporting the securing of enough human resources to execute the measures. The Act on Prevention of Infectious Diseases and Medical Care for Patients Suffering Infectious Diseases sets the basic guideline for infectious disease prevention, collection and publication of information about infectious diseases, instructing people about hospitalization, restriction of employment, and so on. The Act Concerning the Measures for Protection of the People in Armed Attack Situations, etc. sets basic guidelines for protecting the people of Japan, establishment of prefectural and municipal council for resident protection, and evacuation and rescue of residents.

Since the decentralization reform started in the mid-1990s, many authorities about regulation held by the central government were delegated to local governments. The move made local governments set their own ordinances, interpret and carry out the laws, and in cases find themselves in the midst of litigations. The terms "political legal affairs" and "regional legal affairs" are phrases born from the delegation of authorities from the central government to the local governments.

14.2 Administrative System and Societal Safety

14.2.1 Concept of Nation and Societal Safety: Watchman State and Welfare State

The concept of nation that it should keep the necessary minimum duties, primarily of defense, security, diplomacy, jurisdiction, and public projects (roads, rivers, ports, and so on), is called the concept of night-watchman state (minarchism, or small government). F. Lassalle (1884) of Germany criticized night-watchman state concept in the UK at the time and demanded government intervention into wider areas. *Beveridge Report* (1942) in the UK also claimed the needs for a social security system by the state and a public mutual support system. Since around the time of World War II, the theory of welfare state (active state, large government), i.e., the concept that the government should actively be involved in socioeconomic areas, was on the rise.

While the concept of nations shifted from minarchism to active states, T. H. Marshall (1950) of the UK argued that social demand for citizen's rights will shift from basic rights (body, opinion, ideology, conscious, property, freedom to sue) to basic political rights (rights to vote) and eventually to basic social rights (live, social). The trend is to value basic social rights, and the roles of the state and the executing organization the administration has been gradually expanding to today.

14.2.2 *Societal Safety and Administrative Offices*

14.2.2.1 Police and Administration

Police is the administrative organization in charge of maintaining public peace and securing safety of civil life. Police activity, in general, is separated into administrative policing (traffic control and patrol) and judicial policing (criminal investigation, arresting, and house searching) based on the principle of separation of the three functions of the government. The general police force and self-defense army are separate organizations in Japan; however, some countries over the world have military police with the function to maintain orders in military organizations but at the same time also hold the general policing functions of administrative and judicial.

The national police of the Home Ministry Police Affairs Bureau was in charge of police administration in Japan until World War II. After the War, the administration organized local government police (municipality police) under the former Police Act (1947); however, their capacity to counter wide-area crimes went down, and the organizations corrupted (lack of motivation with the policemen and collusion with underground criminal organizations). To counter the situation, the new Police Act was enacted in 1954, and with the establishment of the National Police Agency, prefectural police system went into effect.

14.2.2.2 Self-Defense and Administration

Protecting the country against military threats from foreign countries with military force is defense. To counter military threats with full power including military force added with politics, foreign diplomacy, economics, and scientific technology is called national defense. In Japan, the Ministry of Defense (MOD) is in charge of defense, and the National Security Council, newly established in 1986 after abolishing National Defense Council, is in charge of national defense.

After World War II, the Japanese military was demobilized, and in 1954, the Act for Establishment of the Defense Agency (currently the Act for Establishment of the MOD) and the Self-Defense Forces Act were enacted to establish the Defense Agency (currently the MOD) and Self-Defense Forces. The Self-Defense Forces and three forces of Air, Maritime, and Ground have an overall count of about 240,000 people.

14.2.2.3 Natural Disasters and Administration in Japan

Responding to nature's threats is an important function of the policymaker since ancient times, and today, it is called disaster management administration. Disaster management administration works on preparations for reducing and controlling damages caused by disasters before they break out, on preventing damages upon disasters, and further on recovery from the suffering from disasters. In prewar Japan, the Home Ministry Police Affairs Bureau was in charge of disaster administration at the national level. The postwar disaster management administration was first assigned to the Office for Disaster Management of the General Administrative Agency of the Cabinet and then was transferred to National Land Agency in 1974 and then to the Cabinet Office in 2001. Disaster management administration involves a wide administrative area, and other ministries and agencies carry out disaster management administration that relates to their own administrative fields.

Triggered by the 1959 Isewan typhoon, the Basic Act on Disaster Control Measures was enacted primarily to counter wind and water disasters with local governments (mainly municipalities) at the center of response. Under this law, municipality governments are the primary players in responding to actual disasters (principle of municipalities having the first responsibilities). In recent years, however, more disasters with different sizes and types compared to the time of the Basic Act on Disaster Control Measures are revealing limits to disaster response with municipalities as the main players.

14.2.2.4 Advancement of Scientific Technology and Administration

Advancement of scientific technology in the modern era brought a number of benefits to human; however, at the same time, it caused industrial injuries and destruction of the environment and elevated the risk of nuclear disasters. There is now, therefore, new administrative needs to secure the safety of the workers and citizens.

The history tells us the industrial injuries increased with the development of the industrial revolution. Factory laws in the UK and other countries in the nineteenth century later developed into labor safety administration and labor health administration.

In Japan before World War II, Engineering Bureau of the Ministry of Agriculture and Commerce was in charge of labor safety administration. After the War, labor safety administration was transferred to the Ministry of Labor, and the 2001 reform placed the responsibility with the MHLW. Labor health administration, on the other hand, had been under the jurisdiction of the Ministry of Health and Welfare before and after the War, and since 2001, the MHLW is in charge.

The postwar high economic growth in Japan caused pollutions at various locations in the country. Pollution countermeasure administration and pollution prevention administration started with the 1967 Basic Law for Environmental Pollution Control developed into environmental administration. The Environment Agency was in charge of pollution countermeasure administration and pollution prevention administration, and in 2001, it was promoted to a ministry, and now the Ministry of the Environment (MOE) is in charge. Waste management administration was also transferred from the Ministry of Health and Welfare to the MOE.

Nuclear safety administration, on the other hand, was under the jurisdiction of the Science and Technology Agency. In response to the 1999 JCO criticality accident in Tokai-mura (IAEA 1999), the administration office function of the Nuclear Safety Commission was transfered to the General Administrative Agency of the Cabinet. Further, the 2001 reformation placed the commission and administration office under the Cabinet Office, and “Nuclear and Industrial Safety Agency” was established within the Ministry of Economy, Trade and Industry (METI). Nuclear and Industrial Safety Agency, however, was closed together with Nuclear Safety Commission after the 2011 Fukushima Daiichi NPP accident. In 2012, a new organization Nuclear Regulation Authority to handle all of nuclear safety administration started as an affiliated agency of the MOE.

14.2.2.5 Health Maintenance and Administration in Japan

Once we entered the modern era, urbanization worsened the living environment, and systematic health administration was in need. In general, systematic health promoting activities by the public and private organizations for the health maintenance and promotion of people is called public health. The public health administration in the broad sense in Japan has three activities: (1) general public health administration for households and local societies, (2) school health administration for schools, and (3) labor health administration for the workplace.

General health administration which the MHLW is in charge of is carried out at health centers based on the Health Center Law revised in 1947. The Community Health Act was enacted in 1994 and municipalities are now in charge of basic health services. Prefectural health centers were set in prefectures and ordinance-designated cities, and recently core cities also have the duty to set health centers.

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) is in charge of school health administration. Activities to manage health of students and school personnel and school health activities are carried out under the School Health and Safety Act. The Ministry of Labor was in charge of labor health administration; however, the function was transferred to the Labor Standards Bureau of the MHLW since the 2001 reform. Activities include 347 Labor Standards Offices throughout the country to monitor and instruct proper protection of worker’s health.

14.2.2.6 Traffic and Administration

The advancement of scientific technology developed means of transportation that move with mechanical energy, giving birth to the needs of safety in transportation. Accidents that take place with transportation, including traffic accidents on the road, railway accidents, marine accidents, and aircraft accidents, are called transport accidents.

In Japan, the number of deaths with traffic accidents on the road exceeded 15,000 in 1969. To counter, the Basic Act on Traffic Safety Measures was enacted in 1970, and the Cabinet Office is, since then, in charge of overall arrangement of transportation safety administration (formerly duties of the Management and Coordination Agency of the General Administrative Agency of the Cabinet). Practical safety administration for the railway, marine, and aircraft is primarily carried out by the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) who has jurisdiction over these industries. The National Police Agency is in charge of prevention of traffic accidents on the road and maintenance of orders on the road.

14.2.2.7 Consumers and Administration

The basic social rights we discussed in Sect. 14.2.1 expanded, and it gave rise to the social need that administration should protect safety of the consumers to give birth to a new administrative field of consumer administration (consumer protection administration). After World War II, Japan and other countries over the world recognized the need to protect consumers, and ministries and agencies took on consumer administration. Organizations to specialize in consumer administration, however, started mainly after the year 2000. In other countries, there are cases that consumer administration and industrial administration are carried out in a single organization, or the agency in charge of economy and industry is also looking after consumer administration.

In Japan, choking on hard and small jelly candies, poisoning with China-made frozen dumplings, Paloma gas water heater-caused deaths, and other accidents revealed delay in administrative responses, and enhancing consumer administration turned into an urgent matter. In 2009, as a result, the Consumer Affairs Agency affiliated to the Cabinet Office was established.

14.3 Standardization and Standards

14.3.1 Value and Convenience of Standardization

14.3.1.1 What Is Standardization?

ISO/IEC Guide 2 (2004) defines “standard” as “document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.” Further, “standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits." Similarly, "standardization" is defined as "activity of establishing, with regard to actual or potential problems, provisions for common and repeated use, aimed at the achievement of the optimum degree of order in a given context."

"Standards" define the rules about how products and other matters should be. When standards spread in the society and people take actions following the standards, they will guarantee quality to the set levels no matter who makes the products or who works on them. For the society, standardization is absolutely one way of securing safety (Russel 2005). Not just standards and authentication but also languages and units (measures) are also results of standardization. The first Emperor Qin Shi Huang of the Qin dynasty is historically famous for unifying measures. In our daily life, we are surrounded by standards like cylindrical batteries (A, AA, AAA, etc.), paper size (A4, B4, etc.), USB cable connector shapes (Type A, Type B, etc.), and so on. We can even say that our societies are filled with products and services made with standardization. "Standards" are explicitly written down so their contents spread without misunderstanding. Depending on the geographic, politic, or economic level of the organization conducting standardization, standards are categorized into four levels of hierarchy of international, regional, national, and organizational.

14.3.1.2 Value of Standardization and Problems

Wide transfer of precise information promotes better mutual understanding. The consumer can be assured of safe and secure lives with proper maintenance of product qualities. Companies can widely spread technologies they developed to enhance production efficiency, strengthen competitiveness in the industry, and contribute to environment protection. Further, the products will be assured of compatibility and interface consistency for international competition, and export will grow. In a sense, standardization is a process for gaining initiative in the market. In other words, standardization itself is the result of the competition for gaining initiative.

Members of the World Trade Organization (WTO), with the 1995 WTO/Technical Barriers to Trade (TBT) Agreement, will start to set their national standards in accordance to international standards. In general, rules are advantageous to the one that set them. If one fails to push international standards to one's claim, the products cannot enter the international market, and additional cost to adjust the products to international standards is unavoidable. Japan, with its high technology, can easily clear the international standards; however, for the Japanese industries to continue their prosperity, Japan has to actively take part in developing international standards and strengthen its international influence.

14.3.2 *International Standards: Organization and Activities of ISO*

14.3.2.1 International Standards and International Standardization Organizations

Well-known organizations that develop international standards are the following three:

ISO (International Organization for Standardization)

All fields except electronic and electronic communication

IEC (International Electrotechnical Commission)

All fields of electrotechnology

ITU (International Telecommunication Union)

Information and communication technologies

14.3.2.2 Organization and Activities of ISO

ISO established in 1947 has 163 member countries as of July of 2017. Only one organization from each member country can participate in ISO. Japanese Industrial Standards Committee (JISC) joined ISO from Japan in 1952. The organization of ISO consists of General Assembly, ISO Council, Technical Management Board, Technical Committees, subcommittees, and working groups. The process of developing ISO standards is proposal stage, preparatory stage, committee stage, enquiry stage, approval stage, and publication stage. Primary groups that approve the standards are the Technical Committees. As of July 2017, there are 309 Technical Committees for the various fields.

14.3.2.3 National Standards of Japan

A well-known national standard in Japan is the Japanese Industrial Standards (JIS). JIS is a set of standards based on Industrial Standardization Act. The purpose of Industrial Standardization Act (1949) is to:

> Promote industrial standardization by enacting and disseminating appropriate and rational industrial standards and, thereby, improve the quality of mineral or industrial products, increase productivity and otherwise rationalize production, simplify and make transactions

fair, and rationalize the use or consumption of mineral or industrial products and also contribute to the enhancement of public welfare. (Article 1)

JIS has three standards of product, methodology, and basics. The Minister of the primary industry discusses setting JIS standards to JISC, and based on the discussions and responses at JISC, the Minister sets them. When a product is certified to conform to the product standards by a registered certification organization, the producer can display JIS logo on its products.

14.4 Design Standards for Structures and Systems for Securing Safety

14.4.1 Design Standards for Structures

Our lives are supported by a number of structures including the residence that we reside in, roads, railway bridges, water supply and sewage, and so on. Sudden destruction of these structures from insufficient strength due to a design flaw or degradation over time or unexpected damage caused by a natural disaster is socially not tolerated. These structures, therefore, are subject to control by applicable government offices which enforce design standards so they hold set levels of strength. For example, buildings are administered by MLIT, and the Building Standards Act for "the purpose of protecting the lives, persons and property of the public, thereby contributing to improvement of public welfare" defines "minimum criteria for the site, structure, facility, and intended use."

In addition to buildings, e.g., road bridges, railway bridges, port facilities, tunnels, and gas tanks, there are a variety of structures, and each of them has design standards (technical standards) enforced by an applicable government office. Depending on the type of structure, their physical properties of sites, shapes, dimensions, and necessary strengths vary and different design standards (technical standards) apply to different types of structures. For example, highway bridges, administered by the Bureau of Public Roads of MLIT, follow "Specifications for Road Bridges," while designs of railway bridges, administered by the Railway Bureau of MLIT, are based on "Design Standards for Railway Structures," and port facilities administered by the Port and Harbor Bureau of MLIT are designed based on "Technical Standards for Port and Harbor Facilities." Structures and their design standards are, thus, primarily administered by MLIT, whereas the METI administers industrial tanks, and the Fisheries Agency administers fishing harbors.

Design standards (technical standards) have legal backings. For example, Article 30 of the Road Act regulates that Cabinet Orders determine highways, national roads, and structures of national roads. The corresponding Cabinet Order, the

Government Order on Road Design Standards, Article 35, Section 4, specifies that a MLIT Order determines necessary specifications about standards of road structures. And the MLIT Order, Order for Enforcement of Road Design Standards, regulates that road bridges and so have to hold sufficient safety against earthquakes and so. Specifications for Road Bridges is a Circular Notice that explains methods and standards for judging "sufficient safety," and in general, road bridges are actually designed by referring to "Specifications for Road Bridges and Their Descriptions."

For buildings, the Building Standards Act (2018), Article 20, requires that "to meet technical standards defined by orders about structures and methods necessary for safety." Actual requirements are specified with orders or Circular Notices, instead of laws, because in that way, contents can be reviewed and revised as necessary. Regulations about aseismic design are especially important among design standards in Japan with frequent earthquakes. Foreign countries have a variety of design standards with magnitudes and frequencies that vary with location. With the standards, Japan builds structures with higher strength against earthquakes.

Adding cost will allow building a robust structure. In general, however, structural design balances the cost and benefit, and there is no clear answer to how robust a structure has to be in terms of withstanding an earthquake. Nevertheless, important structures like those built for NPP require extremely high earthquake resistance. The level of earthquake-caused damages socially allowed on structures depends on how the economics have advanced and on past experiences of damages. The criterion is not that easy to determine.

In modern Japan, whenever an earthquake caused major damage, the standards of aseismic design were reviewed. For example, the Building Standards Act enacted in 1950 had new aseismic standards with a secondary design added in 1981. The addition was the results of experiencing the 1968 Tokachi-oki earthquake and the 1978 Miyagiken-oki earthquake so the building would not collapse or fall even in the case of earthquakes with intensity 7. The 1995 Great Hanshin-Awaji earthquake disaster led to introducing a new performance-based standard for easier approval of new construction methods.

14.4.2 Introduction of Performance-Based Design and Qualification/Certification of Engineers

The design process of structures determines material to construct the structure with and the shape of the structure. The less constraints there are about material and shape, the easier it is for the designer to build the structure to his idea; however, assuring safety with the finished structure turns harder. Conventional design standards were based on regulating the specification so safety was assured with the design specification. The idea was limiting the range of the designer's free selection would lead to material, shape, and construction methods that were conformant to the specification in the standard, so safety is assured without elaborate calculation.

In recent years, sophisticated calculation spread to the actual fields to foresee structural response to earthquakes and assure safety. A number of design standards (technical standards), thus, have adopted the concept of performance-based design to allow high level of freedom with the designs. Performance-based design is a method that sets the performance requirement about structures and verifies that the structures meet them. The 1995 Great Hanshin-Awaji earthquake in Japan recorded surprisingly large seismic shakings, and the practice of aseismic design then recognized the need to plan against huge earthquakes at the time of design even if such earthquakes are extremely rare but they can cause serious damages. Building structures that remain completely undamaged upon such earthquakes, however, is not practical, and controlling the predicted damages (structural members that suffer damages and their levels) is effective. Then functional design with higher degree of design freedom but with structural damages within tolerable ranges is now in demand.

Performance-based design with sophisticated numerical analysis is now possible; however, verifying the design is still difficult. We cannot deny possible numerical errors especially with design calculations using computer programs; however, verifying there are no data-input errors or if the program has no bugs is a tedious work. How structures respond to earthquakes requires insights of dynamics based on technical knowledge; thus, only some skilled engineers have chances to recognize flaws in designs. The needs are high, therefore, about systems for qualifying design engineers, approving computer programs for design, and certifying the design results.

14.4.3 Nonconformance of Existing Structures and Fraud by Engineers

Properly designing new structures can meet the required safety level at the time of design. Requirements of design standards (technical standards) are the "minimum levels" at the time when the standards were set, and as the society moves forward, requirements about levels of safety often go up. As a result, existing structures that do not meet the current required design standards (technical standards) are scattered here and there. Such structures are called "existing and nonconforming."

The Building Standards Act of Japan states that for "buildings that currently exist," "These standards do not apply." Therefore, buildings that do not meet earthquake resistance requirement with current design standards (technical standards) can continue to exist for occupancy as "existing and nonconforming buildings." To demolish and rebuild buildings every time the aseismic requirements of the design standards are revised is practically impossible, and thus the regulation may be so for realistic reasons. From the safety standpoint, however, the existence of a number of buildings with low earthquake resistance is a concern. If a building was built without meeting the standards of the time, however, it is illegal and it requires correction. Also, in case of large-scale repair, extension, or reconstruction, the new standards apply (in principle).

In terms of securing safety for the society, even structures owned by individuals or corporations should go through seismic diagnosis and aseismic reinforcement. In 1996, the Act on Promotion of Seismic Retrofitting of Buildings was enforced, and efforts for enhancing seismic resistance have been to be made with buildings with weak earthquake resistance like existing and nonconforming buildings through seismic diagnosis and adequate aseismic reinforcement based on the diagnosis results. The 2013 revision of the above Act specified "buildings for a large number of unspecified people like hospitals, stores, hotels, or so, and large-scale buildings that require special attention during evacuation of their occupants like schools, nursing homes, and so have to go through mandatory seismic diagnosis and the results are published."

As design standards (technical standards) shape up and seismic diagnosis and aseismic reinforcement are promoted, those who actually carry out the safety evaluation are engineers. In 2005, a first-class registered architect was found to have forged a number of structural strength reports. It was assumed he wanted to lower the construction cost by saving parts and materials by falsifying the design calculation. Motivations to falsify aseismic evaluation constantly exist; thus, it is important that engineers need to have the right understanding of rules and conform with standards (engineering ethics) that engineers have to follow. Also, a system to have a third party verify the design and structural calculation and the construction progress so engineers cannot be involved in fraudulent actions is also in need for securing safety of structures.

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Chapter 15
Government Systems for Disaster Management

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Abstract This chapter gives an overview of disaster prevention and mitigation, i.e., disaster management, activities by the government. Such activities by the central government involve a number of tasks including maintenance and management of infrastructures, building disaster prevention plans, and research for promoting disaster management. The central government is also involved in accident investigation for securing safety and security for the people of Japan and arranging systems for public health. Local governments also carry out administration work for securing safety for the residents.

Keywords Accident investigation · Disaster prevention · DMAT · Health center · Local government

15.1 Disaster Management Activities by the Government

15.1.1 Maintenance and Management of Infrastructures

Triggered by the Sasago Tunnel ceiling collapse on the Chuo Expressway of Japan in December 2012, the MLIT started serious countermeasures for old infrastructures. In January of 2013, the MLIT established the Committee on Aging of Social Capital, and in November of the same year, the Relevant Ministries and Agencies Liaison Conference on Aging of Social Capital announced "Action Plans for Life Extension of Infrastructure" (MLIT 2015). The life of infrastructures is, in general, 50 years; however, some keep good conditions even after 50 years since their constructions. The measure extends the life of infrastructures by proper maintenance and repairs without immediately replacing those that have surpassed 50 years since their constructions.

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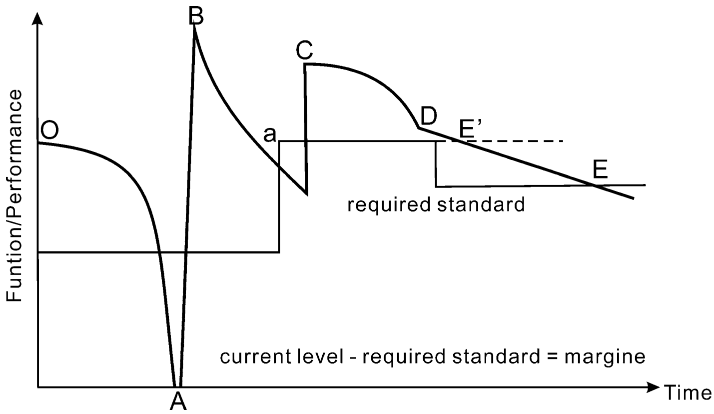

Fig. 15.1 Concept of life cycle. (Modified and redrawn based on Hashimoto et al. 2016)

A recent trend in maintenance of aging infrastructures is a method called asset management. The Japan Society of Civil Engineers, Construction Management Committee, defined asset management as "systemized practical activities for efficient and effective management of social capital, which are shared properties of the people of Japan, for enhancing profit for the people on a long-term basis," and the committee is committed to "continued efforts applying overall knowledge from fields that cover engineering, economics, and business management."

One of the basic concepts of asset management is the "concept of life cycle" (Fig. 15.1). Asset management targets minimization of life cycle cost (LCC) that includes maintenance cost of infrastructures over its entire life cycle in addition to the initial construction cost. First in Fig. 15.1, defining the "function/performance" for the vertical axis is important. Load, strength, and volume are easily quantified; however, such measures like usability or appearance are difficult to quantify objectively. "Function/performance" is a measure for the user to quantify serviceability of whether the social infrastructure can provide the intended "service" or not. "Function/performance" is initially at a level above the required standard; however, it degrades with time. There are cases when the level suddenly drops below the standard with an unexpected event like a natural disaster (A). The level shows a large improvement with reconstruction (B); however, uncertainty in material or construction may cause rapid decrease after level B. A rise in the requirement standard (a) forces reinforcement (C) to raise the level. At level D, implementing a measure to delay the speed of degradation succeeds, however, with a predicted life when the level falls below the requirement standard (E'). The figure shows life extension to level E by lowering the requirement standard by, for example, limiting the use. The margin of an infrastructure is defined as the current level minus the requirement standard, and proper margin against the situation surrounding the infrastructure is in need. The evaluation of current "function/performance" and its forecast of decay determines the time for maintenance. The definition of a decay model requires clarification of the decay mechanism and accumulation and management of measurements and monitoring data.

Continuing maintenance management of aging infrastructures involves the following concerns: (1) Make use of information and communication technology to build a construction system that can perform total management of evaluation, design, and maintenance data and at the same time conform to the international standards of asset management ISO 55000 series. (2) Clarify the responsibilities of the facility manager and make further use of civilian power for sufficient maintenance systems. (3) Pass down information about maintenance management of infrastructures and train human resources. (4) Secure sufficient budget maintenance for developing robots or unmanned aerial vehicles, technologies for efficient maintenance with nondestructive testing, or laser scanning measurement, real-time measurements, and monitoring systems.

15.1.2 Government Plans of Disaster Management in Japan

With over 100 laws, Japan's national disaster management administration failed to mark sufficient effect with individual agencies tackling problems on disaster management separately up until the mid-twentieth century. The problem surfaced with the first wide-area mega disaster of the postwar period in Japan, Isewan typhoon in September 1959. The flooded area reached about 310 km^2 along the coast of Isewan (Ise Bay). During the disaster, over 1000 people were dead or missing in the two prefectures of Aichi and Mie. On the fifth day from the disaster breakout, the central government established the on-site disaster management headquarters within the Aichi Prefectural Government Office building where the deputy prime minister, vice ministers, head of departments from ministries, and staff members of the prefectural governments and Japanese National Railways (currently Japan Railways Group) gathered. The intention was to allow quick decision-making about guidelines and special measures at the headquarters to counter various problems that kept arising.

Later, the central government decided to build the Basic Disaster Management Plan, and prefectures and municipalities the local disaster management plans, so as to promote a comprehensive planned disaster management administration instead of an inconsistent disaster management administration on a one-on-one basis. The national plan completed in 1963 and those by prefectures and municipalities followed. Disaster management committees at the national and local levels arranged discussions among varieties of members from different fields for continuous reviews of the plans. The Central Disaster Management Council has the prime minister as the chairperson and all cabinet officials, heads of primary public institutions, and academic experts as its members. Since the council has leaders of central ministries and public institutions as its members, the nation's Basic Disaster Management Plan can incorporate functions for mutual arrangements of disaster management administration plans by each organization from long-term viewpoints (Cabinet Office 2015). The Basic Disaster Management Plan defines "comprehensive long-term plans for disaster management," "emphasized measures in the central and regional disaster management plans," and "standard measures in preparing central and regional disaster management plans." The actual disaster management measures are carried out based on the Disaster Management Operation Plan and the Local Disaster Management Plan.

The Basic Disaster Management Plan underwent a major revision after experiencing the 1995 Great Hanshin Awaji earthquake to clarify responsibilities for the central and local governments and public institutions. The measures to take in each phase of prevention and preparedness, emergency response, recovery, and reconstruction were spelled out for different disasters of earthquake, storm and flooding, volcano eruption, and so on. Experiences from the 2011 Great East Japan earthquake led to the addition of a new chapter for tsunami disaster management.

Upon a wide-area mega disaster like the Great East Japan earthquake, wide-area support activities are needed. At the same time, local residents have to survive the state when public support is insufficient, and thus disaster management activities in the local communities are extremely important as well. For this reason, a community disaster management plan started since April 2014 to promote disaster management activities among residents (including both individual and corporate residents). The Union of Kansai Governments, with eight prefectures and four ordinance-designated cites in Kansai (area surrounding Osaka and Kyoto) area, has built Kansai Disaster Management Plan under coordinated efforts of its member organizations. The current Basic Disaster Management Plan specifies the need for these regional plans.

The Basic Disaster Management Plan further specifies the need to discuss measures for specific types of disasters and regions as needed. The Central Disaster Management Council, in 2014, established the policy framework for large-scale earthquake disaster prevention and reduction that summarized measures to take for disaster management against the specific mega-earthquakes of Nankai Trough and Tokyo Inland. Further efforts are underway to build comprehensive policies that involve national land policies and industrial policies beyond "disaster management" to build national resilience over the entire nation against major disasters (National Resilience Promotion Office 2014).

15.1.3 Researches on Disaster Management

The Japanese government, with its Basic Disaster Management Plan, promotes researches on science and technology on disaster management. The Basic Disaster Management Plan has a target to "Promote researches, and enhance and reinforce forecasting and observation" of disasters by, in addition to earthquakes, tsunamis, storm and flooding, volcano eruptions, heavy snow, maritime, aviation, railways, roads, nuclear power, hazardous material, large-scale fires, and forest fires. The rest of this section describes researches on earthquake disasters.

Science and technology researches about disaster management involve scientific and engineering researches about the disasters themselves and sociological researches about human actions or information transfer at times of disasters. The Basic Disaster Management Plan places emphasis on promoting coordination among research institutes and administrative bodies through research institutes providing information to disaster management institutes, so outcome of the researches can apply to enhancement of disaster management systems and disaster management policies. Related agencies and ministries and designated public institutes like the Japan Meteorological Agency, MEXT, Cabinet Office, and the like have set their actual research guidelines in their disaster management operation plans based on the Basic Disaster Management Plan.

The 1995 Great Hanshin Awaji earthquake was a big turning point of our researches on disaster management. The impact of the earthquake disaster revealed that accomplishments of investigation and researches on earthquakes had not been sufficiently transferred to the residents and institutions in charge of disaster management. In July of the same year, the Headquarters for Earthquake Research Promotion headed by Director-General of the Science and Technology Agency was established in the General Administrative Agency of the cabinet (the headquarters were transferred to the MEXT with the 2001 reform, and the head is the minister). The government intended to have a single line of promoting efforts that clarified the responsibilities of the investigation and research organizations, so their results can directly make effects on the administration policies. The budget for earthquake investigation and research for the fiscal year (started in April and ended in March of the following year) that followed the Great East Japan earthquake had an increase to reach 35.6 billion Japanese yen (JPY) (about US$430 million), and the annual budget in recent years has been about 11 billion JPY (about US $100 million).

The Headquarters for Earthquake Research Promotion carries out the following research activities: (1) Arrange and analyze observation results of ground motion, study them, and make overall evaluations to publish them monthly. (2) Perform long-term evaluations to estimate probabilities of earthquake occurrence within set timespans and their sizes primarily along major active faults and ocean trenches. (3) Carry out strong ground motion evaluations to estimate the seismic intensities in the surrounding area in cases of specific earthquakes. (4) Publish “National Seismic Hazard Maps for Japan” with probabilistic earthquake prediction maps of probability numbers for regions to suffer seismic activities with timeframes and earthquake movement prediction maps with earthquake source faults identified. Further, for specific probable earthquakes, publish “long-period earthquake ground motion hazard maps” that forecast long-period earthquake ground motions that can cause major damages to structures far from the earthquake sources.

The Headquarters for Earthquake Research Promotion also takes on the role of promoting establishment of the seismic observation network. The seismic observation network is going through the arrangement of setting observation points over the nation land managed by the National Research Institute for Earth Science and Disaster Resilience, Geospatial Information Authority of Japan, Japan

Meteorological Agency, and so on. The 562 high-sensitivity seismographs in 1996 greatly increased to cover 1498 points over the nation in 2016. Similarly, broadband seismographs went from 82 points to 189, strong motion seismographs from about 2809 to 2853, and GPS continuous monitoring facilities from 716 to 1492.

15.2 Public Systems for Societal Safety

15.2.1 Accident Investigation

15.2.1.1 Significance and Purpose of Accident Investigation

An effective way in preventing reoccurrence of an accident is to investigate and analyze the accident cause to prevent similar accidents from repeating and learn knowledge and lessons effective in preventing other types of accidents (Abe 2011). The world's first commercial jet plane Comet in the UK went through accidents of falling apart while in-flight from 1953 to 1954. The accident investigation identified the cause of metal fatigue of the fuselage with repeated pressurization and depressurization. The knowledge gained from the investigation greatly contributed to enhancing safety of airplane operations that followed. Accident investigation is so effective in accident prevention and safety enhancement (Ministry of Transport and Civil Aviation 1955).

15.2.1.2 Types of Accident Investigation

Categorizing accident investigation based on the organizations that carry them out, we have accident investigations by (1) permanent public organizations, (2) temporary public organizations, (3) government or administrative organization as part of its duty, (4) the organization responsible for the accident, (5) third party from the civilian section, and so on. Also, separately from these accident investigations, many countries in the world, including Japan, have their police force investigate accidents in case of deaths or injuries. The police investigation is intended for criminal prosecution of causing death or injury through negligence in the pursuit of social activities; however, since it sometimes identifies the cause to certain levels, it can be deemed a type of accident investigation.

The most important type of investigation among the above is that by permanent public organizations that aim not at pursuing the responsibility but at finding the accident causes, extracting the lessons, and preventing repeating the same accident again. The National Transportation Safety Board (NTSB) of the USA is internationally well known to be an investigation organization with such purposes.

The NTSB was established in 1967 as an organization under the US Department of Transportation. The board, however, to keep independence in its accident investigation, demerged from the Department of Transportation into an independent federal institution. Accident investigation is nothing but serious work to identify flaws and weaknesses of organizations or systems. At times, it functions to point out defects in administrative regulation. Accident investigation, therefore, has to keep independence not only from those responsible but also from related administrative organizations.

15.2.1.3 History of Accident Investigation

Accident investigation by permanent public organizations started early in transportation. In 1951, the International Civil Aviation Organization (ICAO) adopted an article from the Convention on International Civil Aviation about the Standards and Recommended Practices for Aircraft Accident Inquiries and designated it as Annex 13 (ICAO 2016). When an aviation accident breaks out, contracting countries to the convention carry out accident investigation following this annex. Japan, in 1974, established the Aircraft Accident Investigation Committee within the Ministry of Transportation (now part of the MLIT).

A number of countries in the world started investigations of maritime accidents since before World War II. In Japan, the Marine Accident Inquiry Agency (formerly Marine Court) was established in 1949, and it continued its investigations into accident causes and disciplinary actions to marine personnel as an affiliated agency of the Ministry of Transportation up until 2008. For railway accidents, on the other hand, investigations were made by railway companies or administering agencies since old times, however, not by permanent organizations. Investigations of railway accident by a permanent organization in Japan started in 2001 with the establishment of the Aircraft and Railway Accidents Investigation Commission (JTSB 2018).

In recent years, with the growing international social concerns for safety, movements to establish permanent accident investigation organizations are on the rise among advanced countries. Especially for transportation accidents, the International Transportation Safety Association (ITSA) was established in 1993 as an international union for accident investigation. As of June 2017, accident investigation organizations from 16 countries, including Japan, have joined this association.

15.2.1.4 Permanent Accident Investigation Organizations in Japan

Not all accidents in Japan undergo investigation by permanent accident investigation organizations. Fire departments and the Fire and Disaster Management Agency investigate fires that amount to about 40,000 annually, and the police looks into the 500,000 or so annual automobile accidents that cause deaths or injuries. An extremely rare accident takes a temporary investigation committee each time. For example, the 2011 Tokyo Electric Power Company (TEPCO)-owned Fukushima Daiichi NPP accident led to separate investigation committees, one by the central government and one by the diet.

As of now in October 2017, we have four permanent accident investigation organizations: the Japan Transport Safety Board, Consumer Safety Investigation Commission, Commercial Vehicle Accident Investigation Commission, and Medical Incident Investigation Support Center. The Japan Transport Safety Board established in 2008 with the merger of the Aircraft and Railway Accidents Investigation Commission and part of the Marine Accident Inquiry Agency carries out investigation of aviation, railway, and maritime accidents and serious incidents to identify the causes, prevent recurrence, and reduce damages. The Consumer Safety Investigation Commission started in 2012 for accidents related to consumer products, food, facilities, and services. The 2014 Commercial Vehicle Accident Investigation Commission investigates accidents with commercial vehicles of buses, taxis, and trucks and the 2015 Medical Incident Investigation and Support Center medical accidents (Medical Safety Promotion Office 2016).

15.2.2 Public Health Systems

15.2.2.1 Establishment of Public Health Systems

Hippocrates from the fourth century BC described that clean water and air and proper housing have strong correlation with the health. In the fourteenth century, Europe faced an outbreak of plague, and quarantine started at newly placed health offices in the northern Italian cities of Florence and Venice (Cipolla 1981). The system of public health that carried on to date started in the nineteenth-century UK. In the UK, commerce and industries showed rapid growth, and with the increase in city populations, the health environment in cities declined. Large cities like London suffered outbreaks of infections like cholera entering the vicious spiral of poor hygiene, disease, and poverty. The social systems at the time could not handle the situation, and Edwin Chadwick built the new system of the Health of Towns Associations in local communities with professional staff to perform duties and established the Public Health Act in 1848. This system spread to the rest of the world as a public health system (Tatara 1999).

15.2.2.2 Definition of Public Health

The forming of systems for providing medical services deemed the public health system established in the nineteenth century unnecessary. Even with such systems shaped, however, medical service alone could not solve many health problems like dealing with spread of infections. Since around the 1980s, many countries went through reforms of their public health systems. The UK redefined and promoted public health to mean "Science, technology and policies to assemble various forces of the societies to promote and protect health of the people for their health and peace, to prevent illnesses, and extend their lives" (Acheson 1988).

15.2.2.3 Public Health in Japan

The "Medical System (1874)" promulgated in early Meiji era started with an article on health administration to introduce the system of public health into the country. Public health system, however, made its way clear for the first time with the Constitution of Japan in 1947 (Prime Minister of Japan and his Cabinet 1947). Article 25, Section 2 of the Constitution clarified the nation's responsibility in improving and promoting public health and further assigned local public organizations to carry out public health operations. The postwar public health operations developed around public health centers based on the 1947 Health Center Act. Since 1978, the change in the policy made municipalities build their health centers and increase their municipality health center staffs, so the municipalities could play the central roles in public health. In 1994, the Health Center Act was amended to "Community Health Act," and municipalities were legally assigned the central roles for providing basic public health functions of health, welfare, and nursing servicing for the citizens (Tatara and Okamoto 2009).

Cities with health centers (ordinance-designated cities and core cities), in addition to health centers, have "Local Research Institutes of Hygiene" (Tatara and Okamoto 2009). The MHLW has built "quarantine stations" in primary ports and airports. We also have a number of special institutions and research centers, e.g., the National Institute of Infectious Diseases, National Institute of Public Health, National Institute of Health Sciences, and so on. In addition to these administrative institutes and organizations, the private sector has built the Japan Public Health Association, Japan Food Hygiene Association, and so on to support the public health system.

15.2.2.4 Health Center Operations as Defined in Community Health Act

Health centers are specialized institutions for public health activities with medical doctors, public health nurses, public health inspectors (environment, food, pharmaceuticals, and inspections), and so on. Article 6 of the Community Health Act defines the following 14 tasks as duties for health centers:

- Enhancing concepts of community health
- Dynamic regional population and other statistics about community health
- Improving nutrition and food hygiene
- Environmental health concerns like living space, water supply, sewage, garbage disposal cleaning, and other matters related to environmental hygiene
- Medical and pharmaceutical concerns
- Matters about public health nurses
- Improvement and promotion of public health activities
- Health of mothers, infants, and elderlies
- Dental health
- Mental health

- Health of those with infections without established cures and those in need of long-term treatment due to other special infections
- Prevention of AIDS, tuberculosis, venereal diseases, contagious diseases, and other diseases
- Hygienic testing and examination
- Other matters for protection and promotion of health of community residents

15.2.3 Establishment of Emergency Lifesaving System

15.2.3.1 History of Emergency Medical System in Japan

The 1947 Fire Defense Organization Act triggered the establishment of emergency medical service systems in Japan with municipalities in charge of administration of defense against fires. The year 1961 marked the establishment of a universal healthcare system, and the number of medical institutions greatly increased to accommodate emergency patients. In 1963, fire departments were assigned with the tasks of emergency transportation. In 1964, the notification system of emergency medical institutions started, and patients with first-degree emergencies (mild cases) and second-degree emergencies (moderate cases) were subject to emergency medical service within municipalities.

Patients with severe cases of third degree, however, needed institutions specialized in lifesaving with specialized medical doctors trained for emergency medical service. Such systems were not organized until university hospitals that were training such medical doctors started to accommodate third-degree patients. In 1967, the Osaka University Hospital established the emergency department to accommodate third-degree emergency patients. It was the first among all university hospitals in Japan. It also started a course on emergency medical service for education and training of doctors specialized in emergency medicine. Osaka Prefecture in 1979, starting with the Osaka Prefectural Senri Lifesaving Emergency Center, built third-degree lifesaving emergency medical centers in blocks that divided the prefecture. The emergency medical administration by Osaka Prefecture spread throughout the nation (Kidokoro 2001). Currently further specialized "Advanced Lifesaving Emergency Centers" for extensive burns, severed limbs, acute intoxication, and so on are spreading throughout the nation.

The probability of saving an emergency patient is limited with only the doctor's treatment after reaching a hospital, and in 1991, the system of emergency lifesaving technician started, so the technician can perform lifesaving treatment during transportation of emergency patients. Many ambulance team members now carry the qualification of emergency lifesaving technicians to provide resurgent and lifesaving treatment.

15.2.3.2 Base Hospital upon Disasters and Formation of Medical Teams

When a major wide-area disaster like the 1995 Great Hanshin Awaji earthquake breaks out, the regular emergency medical service system based on municipalities cannot handle the large number of injured patients. A detailed analysis of response cases to emergency patients at the time of the Great Hanshin Awaji earthquake led to the conclusion that such a situation needs a “Disaster Base Hospital” and a “Disaster Medical Assistance Team (DMAT)” (Kondo et al. 2009). Arranging hospitals that can serve as bases of lifesaving emergency medical service and organizing DMAT for the time of disasters are underway since 1996.

A disaster base hospital, in response to a request by the prefectural governor, accepts the injured immediately after the breakout of a disaster and dispatches medical teams as needed. DMAT is a medical team with various members including doctors, nurses, and specialists (emergency lifesaving technician, pharmacist, clinical engineer, clinical laboratory technician, physiotherapist, occupational therapist, radiology technician, social welfare counselor, healthcare professional, clerk, and so on). It carries medicine and medical equipment to disaster-struck areas with medical staff to perform independent emergency medical service.

Prefectures have “Prefectural DMAT” in preparation for medical needs upon disasters, and the MHLW has “Japan DMAT” to respond to major disasters. The two cooperate in disaster-struck areas in providing medical support of long- and short-range transportation, setting up temporary medical camps, and supporting local hospitals.

At the time of the Great Hanshin Awaji earthquake, hardly any helicopters transported emergency patients for lifesaving. The administration, thus, started to deploy Doctor-Heli (doctor helicopter) around the nation, so they can transport patients to remote medical facilities with a doctor, a medical nurse, or an emergency lifesaving technician onboard. The 2011 Great East Japan earthquake was the first major disaster for the emergency medical facilities and medical teams to go fully operational.

It is now clear that setting up lifesaving emergency medical service systems is insufficient in saving victims of disasters. After the Great Hanshin Awaji earthquake, people found that although emergency medical service immediately after the disaster outbreak is important, people tend to worsen their medical conditions or in some cases decease, during the mid- to long-term evacuation that followed. The need for teams for mid- to long-term medical and health-supporting activities arose in disaster-struck areas to follow DMAT after its departure after several days of action. After the Great East Japan earthquake, the Japan Medical Association formed the Japan Medical Association Team (JMAT) and dispatched them, for the first time, to areas struck by the earthquake. Upon outbreak of a disaster, not just Japan Medical Association but national and public hospitals and private medical institutions like the Japan Red Cross Medical Center form medical teams for entering disaster-struck areas to perform medical services.

15.3 Local Government and Societal Safety

15.3.1 Safety Securing Duties of Local Governments

Article 92 of the Constitution of Japan states that "Regulations concerning organization and operations of local governments shall be fixed by law in accordance with the principle of local autonomy." The principle of local autonomy consists of organizational autonomy and residential autonomy. Organizational autonomy acknowledges local governments, independent from the nation, at regions, and it is the principle of voluntary administration under the responsibility and intention of the local governments for securing safety and security for the residents. Residential autonomy means that local autonomy is based on intentions of the residents. Under local autonomy, we have to "protect safety and security of our community with our own hands."

Administration by local governments cover a wide range of policing, firefighting, disaster response, environment protection, public health, health management for the residents, and welfare policies. For fairness and equality over the entire nation, these administrative services by the basic local autonomies and the municipalities work in coordination with prefectures responsible for wide-area administration, under the control by the central ministries and agencies.

For example, we have the Consumer Affairs Agency (CAA) that started in 2009 as a national institution for protecting consumer's safety. The agency has centralized control of claims from consumers filed at consumer affairs center in prefectures and municipalities. Problems reported to consumer affairs centers cover a wide range of incidents, in fact, almost everything, like purchases through the Internet, fraudulent businesses for the elderly, fraud in home remodeling, accidents with playground equipment, troubles with home medical devices, troubles with cosmetic medical treatment, dangerous drugs, loan sharks, forged credit cards, and malignant business deals (CAA 2017).

Organizational charts at entrances of city halls show that local governments have varieties of departments. For example, a department in charge of crisis management supports activities by disaster management organizations or carries out activities for promoting consciousness about disaster management among the residents, so the power of disaster management is enhanced in the community. The firefighting department keeps daily activities to immediately respond to firefighting and rescue requests for saving lives of the residents. A welfare-related department carries out fine operations to support those in need, like elderlies or handicapped. A department in city planning keeps roads, parks, and public areas in good conditions for keeping the safe and secure community. The board of education works on the safety management systems at school, so children are not involved in incidents.

Our modern societies have to face a large number of risks, and the responsibilities for local governments are growing. The staff are busy carrying out their duties in protecting the safety for the residents. And once a major disaster breaks out, the staff has to quickly gather at their positions and conduct disaster response under the instructions from the headquarters. Most people used to think of local governments as terminal nodes in the top-down system with the central government at the top; however, in fact, they have the heaviest responsibilities in keeping safety of local regions.

15.3.2 System for Securing Safety by Local Governments

This section overviews the level of involvement by local governments to securing safety for the residents. Through this analysis, we will try to roughly grasp the current problems. We will especially compare the police and fire stations in Sect. 15.3.1 that are somewhat close entities to the residents in their efforts of protecting safety and security for them.

Police headquarters are set for each prefecture, whereas fire department headquarters are located for municipalities. A police headquarter then places police booths, police boxes, and police stations in its prefecture, and a fire department headquarter places fire stations and substations in its municipality. The system allows police officers and firefighters, familiar with the regional roads, to swiftly and accurately carry out their missions.

In Japan fiscal year (starts every April of the year) 2016, all the police station staff accounted 288,000 with all prefectures combined and fire department staff from all municipalities 163,000. They, respectively, amount to 10.5% and 6.0% of all local public employees. The Japan fiscal year 2015 expenditure amounted to, in JPY, 3231 billion (about US$30 billion) for the police force and JPY 2097 billion (about US$20 billion) for the firefighters (MIC 2017). The figures, respectively, amounted to 3.3% and 2.1% of total local government expenses. The numbers tell us that local governments spend huge amounts of manpower and cost in securing safety for the residents.

Revenue shortages in local finances these days are forcing each department to streamline (rationalization and higher efficiency) the administration. The transition of local expenses during 10 years of 2005–2015 showed consistent ratio for the firefighting expenditure; however, the police spending declined in its ratio to overall local expenses. Revenue shortages for local finance affect local government operations of securing safety for the residents and raise big concerns (MIC 2017).

As the societies grow complex and advanced, operations for securing safety for the residents are turning internationalized, advanced, and complex as well. The reality is demanding preparedness for the following concerns (FDMA 2016):

(a) Internationalization: Local administration is undergoing rapid internationalization. Crimes and troubles by foreigners are problems not just for the police but also for emergency transportation for the firefighters. We are also concerned about terror attacks by foreign terrorist groups, and the police and firefighters have to quickly prepare against nuclear, biological, and chemical disasters (NBC disasters).

(b) Advancement: Crimes that take highly advanced knowledge for suppressing them are increasing these days. They are cyberterrorism targeting weaknesses of information security, fraud over international networks, money laundering, and so on. Equipment and systems for fire extinguishing and rescue are highly advanced and sophisticated. The measures that require high costs are demanded just like with internationalization in (a).
(c) Complication: In case of a mega-scale disaster, we can foresee added complication in the disaster-struck areas with trains overturning and multiple collisions, explosions at chemical factories, and terror attacks. We thus need to be prepared to apply "triage" that prioritizes how to apply limited resources to the troubled events. The streamlined organizations with short budget have no margin and will have to make hard decisions.

As we described above, systems for protecting safety of citizens have to make continuous efforts to reform themselves with the changing requirements of the time and societies. Otherwise, the systems will be quickly outdated and weakened. There are expectations toward the buzzwords "New Public Commons" or "Government 2.0" (Chen 2011) based on "residential autonomy" for local autonomy that makes use of cooperative efforts by many of the residents.

15.3.3 Local Governments and Emergency Drills

Administrative bodies of the nation and governments make disaster management activities primarily targeting natural disasters. With disasters of larger magnitudes, however, that is, the more we acknowledge the situation as severe, response and recovery by the administration fail to provide sufficient functions. A white paper on disaster management in Japan also pointed out limits to public aid: "It was clear that administration alone had difficulties in providing quick support for all the disaster victims and there were cases that administration functions suffered damages and were paralyzed in providing their intended functions in case of mega-scale wide-area disasters like the Great East Japan earthquake" (Cabinet Office 2015).

With the assumption that disaster management measures by administrative organizations are limited, promoting disaster management activities in households and regions is one of the important activities for local governments. Disaster education and emergency drills are activities for promoting disaster management activities in households and local regions.

The most common emergency drills by local governments are regional overall emergency drills. Regional overall emergency drills are trainings for a number of disaster management-related organizations, and thus participants are often limited to experts. These events, thus, often end up being just chances for local residents to observe results of training by experts. The drills need to involve more regional residents by, e.g., having them experience earthquake simulator trucks or initial actions in fire extinguishing or having them walk from their homes to the training ground.

In recent years, communities organize “shakeout drills” that involve wide areas like the whole prefecture or municipality to coordinate emergency drills at companies, schools, and households at the same time on the same day. Shakeout drills are major-size emergency drills that started in 2008 in California, USA (Jones and Benthien 2011), and they are spreading throughout the world. In addition to shakeout drills are “plus one drills” that have the participants add one additional disaster management activity like checking the emergency supplies or dangerous spots. Shakeout drills and plus one drills are one of the most important trainings led by the local governments for the promotion of self-support and mutual support by regional residents.

These emergency drills are often carried out in Japan during a specific period. The most popular is the “Disaster Preparedness Day” on September 1st. September 1st is the day the Great Kanto earthquake hit in 1923. It is also the time of the year when typhoons hit. The cabinet meeting set the day in 1960 as the Disaster Preparedness Day to promote training to understand the threats of disasters. In addition to Disaster Preparedness Day, we have from past disasters, Disaster Reduction and Volunteer Day (January 17), World Tsunami Awareness Day (November 5), and so on.

Local governments need, in addition to simply remembering past disasters on the above specific days related to disaster management, to have regional residents to actually realize that disaster management is accomplished for the first time upon everybody’s cooperation.

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Chapter 16
Systems for Disaster Management in the Private Sector

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Abstract Disaster management is not just for the government. Various sections of the private sector carry out disaster management activities. At the time of disasters, volunteers and NPOs are well known. Corporations, on one hand, prevent accidents within and at the same time take measures to respond quickly in cases of emergency situations. The insurance system is another method of risk management that has been around since old times.

Keywords BCP · Insurance · Labor safety · Mutual aid · NPO · Volunteer

16.1 Natural Disasters and Nonprofit Organizations

16.1.1 Disaster Relief and Nonprofit Organizations

When a natural disaster that exceeds a certain level strikes, prefectures and municipalities that suffered damages set up disaster response headquarters according to local disaster management plans. The headquarters take the lead in the system for emergency response and later measure up to the point of recovery and reconstruction. In case of small disasters, the top-down organization within administration can provide effective response. The 1995 Great Hanshin Awaji earthquake in Japan, however, revealed the limits of administrative response. Large-scale disasters produce a large number of situations that require quick judgments and decisions at the same time, and administrational entities, which place priority on fairness of their response, hesitate in distributing the resources at hand until the entire picture of the damages becomes clear and the responses end up being late.

Initial fire extinguishing, grasping the damage levels and running evacuation shelters, in general, are tasks for self-support by family members or mutual support

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by residents in the areas. At the time of the Great Hanshin Awaji earthquake, however, families and residents had lost their capacities for problem-solving with declining birthrate, aging population, and urbanization, and many of the regional communities could not properly provide self- or mutual support by themselves.

What made up for these gaps of limits with public support and self-/mutual support were "goodwill citizens." Once images of devastating damages went on air, huge amounts of people, supply, and relief donations poured into the disaster-struck areas. Especially noteworthy were the "disaster volunteers" that exceeded about 1,380,000 a year (estimate by Hyogo Prefecture). They entered the disaster-struck areas and offered their labor in place for the functionally failed administrative organizations.

The regions, however, were not prepared to accept the volunteers, and a number of problems arose. This experience led to a system to have a window to accept general volunteering citizens separate from registration of skilled supporters in the disaster response system in the regional disaster management plan revised after the earthquake. Further, the volunteer center (VC), set by the Council of Social Welfare and operated through ordinary times, expanded its function to start "Disaster Relief VC" when needed to register volunteers and dispatch them to proper places.

Disaster Relief VCs turned into organizations for disaster response systems of Japan to promote "cooperative support" that compensates the limits of public support and also helps self- and mutual support. While social movements were on the rise to promote the establishment of foundations for socially contributing activities by goodwill citizens, the Act on Promotion of Specified Nonprofit Activities was enacted in March 1998, and a large number of NPOs, specialized in disaster support, were born. Earthquake volunteer activities during the Great Hanshin Awaji earthquake placed large effects on the arrangement of disaster response systems in Japan and the formations of the private nonprofit sector.

The years that followed the Great Hanshin Awaji earthquake suffered disasters at regions, and every time, "cooperative support" centered about Disaster Relief VCs made significant activities. The foundation of activities for Disaster Relief VCs gradually shaped with procurement of activity funds and management training; however, around 10 years after the earthquake, limits of the system started to emerge. Disaster Relief VC activities that dispatched large number of citizens that may lack experience or skills but were highly motivated have been highly praised. In fact, in 2004 when 10 typhoons landed on Japan, over 80 Disaster Relief VCs were set within the single year, and, at one time, 60,000 volunteers worked in disaster-struck areas. Coordinating the work of a variety of volunteers, however, that required large management work and running Disaster Relief VCs were large burdens to Council of Social Welfare offices. Another drawback was that Disaster Relief VCs had general citizens playing the central roles of activities, thus could only accept support requests possible for anyone and had to turn down requests that required special skills.

The 2011 Great East Japan earthquake caused damages over a wide area crippling the public organizations in the area, and expectations were high from the beginning for "cooperative support." The real needs, however, were more for organizations that could move large amounts of resources or specialists that could work under severe work conditions, rather than civilian support for individual victims. In addition, lack of resources in the disastrous areas caused difficulties in building activity centers for the volunteers and delayed the startups of Disaster Relief VCs. The needs for special skills and large resources were met by private companies, nongovernmental organizations (international NGOs), and domestic disaster-related NPOs that had accumulated experience before the earthquake disaster (Suga 2018).

Cooperative support for disaster-struck areas today is shifting toward coordinated activities through liaison meetings among NGOs, NPOs, administration, and the Council of Social Welfare. At the time of Kumamoto earthquake in 2016, the governments and private sectors provided a new form of support to the disaster areas and victim liaison meetings among a variety of organizations and entities.

16.1.2 Disaster Recovery and Rise of Social Business

During the Great East Japan earthquake, as we discussed in the previous section, NPOs with specialized skills came to play important roles, and a number of organizations and companies started support for disaster-struck areas in business-like fashions. Examples of large private corporations that applied its own business strategies, as part of its corporate social responsibility (CSR) activities, to support disastrous areas include Amazon that provided relief goods using “wish lists,” Honda that gave road traffic status information using its own automotive navigation system, and so on. There were a large number of other organizations and companies that posted goals to meet social needs. NPO Katariba applied its know-hows in career learning programs for high school students to start a private academy for disaster victim children in the city of Onagawa in Miyagi Prefecture. NPO Florence that provides childcare for children with illness started an indoor playing facility for children in Fukushima Prefecture. The Music Securities, Inc. applied the system of microfinance to start a service to solicit general investors to invest into disaster victim companies and collect reconstruction funds.

These business entities offer their services at cost, and they are continuing their businesses by receiving compensation from the users. Their abilities to carry on the reconstruction support activities without having to rely on grant money from the government or charity donations give them solid strength compared to other NPOs or volunteers.

The Great East Japan earthquake damaged a large number of companies mainly along the coast, and many employments were lost as well. Social business companies, like we described above, receive compensation from the users. Therefore, they are expected to offer employments in addition to providing services to support disaster victims. The METI, with the objective of reconstructing the regions from the disaster, started to support social business startups, and a large number of them started and contributed to reconstruction of the areas and employment offerings.

16.2 Accident Prevention Activities by Companies

16.2.1 Accident Prevention Activities

Accidents and disasters that happen through corporate activities are industrial accidents if workers contract sickness, are injured, or are dead. Even if the effects of an incident are only physical, it may cause long-term influences on the surrounding areas. If an event causes harm to a third person unrelated to the corporate activities, it turns into a social issue. For this reason, whatever the industry is and in whatever form, corporations need to work on accident prevention in various forms, so they will not harm their workers with employment and also will not cause bad effects on the societies and regions around them.

Accident prevention activities with companies, in general, develop through building proper safety and health management systems, conforming to regulations about labor safety and health, and promoting voluntary activities in safety and health. The activities and methods differ with companies and job types, and further improvements are implemented to continue enhanced activities for accomplishing better accident prevention.

Educating the employees about safety knowledge is also important in accident prevention. The Industrial Safety and Health Act of Japan obligates the employer to provide safety and health education to its employees upon their employment and start of hazardous operations. The act also requests employers to make efforts in education for skill improvement and health for safety managers.

Depending on the type of work and sizes, corporations conduct a variety of accident prevention activities. In recent years, activities in accident prevention are on the table for different businesses (manufacturing, service industry, disaster recovery and reconstruction, and so on), accident types (explosion, chemical substance, heat attacks, and so on), and the actual concern (elderly worker and overwork, long working hours, and so on).

Accident prevention activities alone, of course, cannot fully stop accident breakouts. For example, the “close call reporting” that has workers’ report about their own experiences tends to end up being a collection of reports of actions like “slipped” or “fell down” that the worker can recognize, and the reporting system seldom picks up cases that are hard to recognize like “misunderstanding” or “slip of memory.” Only alerting the operators by writing to “be careful” in the operation manual has difficulty in its effect of preventing errors. Further, whatever the process is, new operations can expect a certain level of effect because they are new to the operators; however, as time passes, the operators get used to the operations and tend to forget cautions in the manuals (Oiri 2008). Thus, not suffering from disasters or no legal violation for now is not a good enough reason to carry on the current accident prevention activities. We should all continue aiming at further safety by identifying and organizing problems and concerns in our efforts to implement improvements.

16.2.2 Safety Management

Companies with their involvement in accident prevention activities lowered the number of industrial accidents; however, the drop has leveled off since about the 1990s. Now the movement is to implement occupational safety and health management systems (OSHMS) for preventing industrial accidents and improving levels of corporate safety and health.

Discussion has been made about the reason for the leveling off of decline of industrial accidents. What were pointed out include the following: (1) Accident prevention activities are left to those in charge and post-accident measures are merely for formality, (2) retirement of baby boomers (born 1947–1949 in Japan) has made it difficult to carry on the know-how of safety in the fields, and (3) advancement in the industry diversified the risk factors that conventional measures cannot handle. When OSHMS guidelines were underway by the International Labour Office (ILO), MHLW of Japan announced *Guidelines on Occupational Safety and Health Management Systems* in 1999 to introduce, spread, and have companies implement OSHMS. The guideline was revised in 2006, and risk assessment, the central contents of OSHMS, has included the actual implementation of "Guidelines for Investigation of Danger and Harm, etc."

OSHMS has the following four features:

1. Company-wide promotion

   Roles, responsibilities, and authorities are defined for system managers at each level (overall manager, department manager, and safety and health manager) to properly operate the system, periodically audit and review the system, and reflect opinions of workers in the operation.
2. Performing risk assessment

   Investigate dangers and harm to estimate the risks. Set priorities for reducing risks, examine the risk reduction methods starting from higher priorities, and execute the measures.
3. Autonomous system based on PDCA cycle

   Continue execution of the autonomous activities of (plan, do, check, act, etc.). Target improvement of safety and health standards at the workplace in a spiral manner through the checked items during system audit.
4. Procedural, written, and recorded

   For clarifying "when, who, what, and how," write out safety and health guidelines, roles, responsibilities, and authorities of managers at each level, and procedures of reflecting workers' opinions, risk management, investigation of accident causes, and system audits. Also record necessary steps taken along the execution.

Introducing OSHMS was not easy in both terms of implementing a new method and coordinating it with existing measures. OSHMS are hardly in full operation, especially with small- to mid-sized companies with limited resources, and there are a number of concerns left until it is fully spread and implemented.

16.2.3 Labor Safety and Health

After the industrial revolution, advancement of mechanical technologies and mass production systems led to employment of women and even children. At the time, the concept of protecting workers was weak, and a number of problems arose including long hours of labor of 12–13 h a day, poverty with low wages, a number of infections caused by these reasons, and so on. In 1833, the UK government passed the Factory Act to restrict labor by women and children. Daily work hours, however, had to wait until 1947 when a limit of 10 h a day was enforced.

Also in Japan, the rapid modernization and industrialization that started in the Meiji era caused serious problems of accidents and infections at factories. The social mood at the time, however, placed priority in economic growth to compete with the European and American leaders, and activities for workplace safety and accident prevention were not well accepted. On the other hand, engineers, dispatched to trips to Europe and America to learn know-how of modern industries, came back with knowledge about safety and accident prevention and tried to spread the methods in Japan. Some new leaders emerged who led efforts in assuring safety after experiencing distressful accidents that involved close people to them. The birth of modern labor regulation in Japan was its Factory Act enforced in 1916 that was over 30 years since it was first drafted. Then the Labor Standards Act was enforced in 1947 and the Industrial Safety and Health Act in 1972 for establishing the framework for protecting workers from job-related injuries, illness, and deaths.

The modern society has a big variety of industry types and job types and so are the systems for safety and health management. The business owners and workers, therefore, not only have to conform to the regulations, but it is important for them to continue efforts for improvement by building systems that suit the business operations.

16.3 BCP and Crisis Management

16.3.1 Internal Control Systems for Corporations and Crisis Management

The Great East Japan earthquake that broke out on May 11, 2011, caused enormous damages to companies. "Research on Effects of 'Great East Japan earthquake' on Publicly Listed Companies" (Tokyo Shoko Research 2011) reported that of the 1908 publicly listed companies, 652 (34.2%) had "partial shutdown of sales or operation." Corporations have to continuously operate their businesses, and preparing crisis management against large earthquakes and accidents is indispensable for them.

Crisis management is defined: "Strategic protective actions taken within a community to prepare for, respond to, or recover from the occurrence of a crisis" (Penuel and Statler 2010). Risk management is a measures to prevent occurrence of risks, whereas crisis management is a concept about countermeasures after a crisis like a disaster has occurred.

A corporation prepares its crisis management system as follows: First is the setting of escalation rules. Set a rule, so when a disaster or an accident breaks out, the field quickly transfers the information to the top management. Second is the formation of a crisis response group. The top management forms emergency crisis response headquarters when it receives information about a disaster or an accident and judges if the incident is a crisis. Members and the location of the emergency response headquarters should be set beforehand and defined in the crisis management manual. Third is action plans have to be prepared. At the time of a crisis breakout, there will be confusion, and measures for the emergency crisis response headquarters to take should be defined and compiled beforehand. Fourth is the crisis simulation training. Periodically conduct simulation training with a hypothetic crisis to extract problems and to review the crisis management system.

Internal control system is a name for a combined corporate group system for risk management, crisis management, and compliance. The Companies Act enacted in 2005 obligated business owners to construct internal control systems. The Financial Instrument and Exchange Act enacted in 2006 enforced internal control reporting to publicly listed companies. The two acts urge business owners to organize crisis management systems, and they affected the spread of guidelines by the government as we will discuss later.

16.3.2 Crisis Management and BCP

Business continuity planning (BCP) is defined as "Plans identifying all the process and actions necessary to permit an organization to perform its crucial functions and activities during and after a disaster" (Penuel and Statler 2010). In other words, BCP is plans to prepare during regular times, about how to continue or quickly recover from a major disaster or accident that is a predictable risk that stops the business.

An actual BCP is prepared in the following manner: First is risk analysis. Identify risk events that will stop the business, and determine the worst scenario for the corporate group. Second is to set the basic guideline and identify the important businesses, that is, to identify the business important for the business group and ones that are demanded socially. Third is to set the recovery target. Once important businesses are identified, set the time to recover them from the outbreak. And fourth is to set the plans for restarting the business. Identify necessary resources for the restart, and build plans for the business restart. Once the four steps are complete, periodically carry out crisis simulation training to identify problems by reviewing the BCP.

Recovery from disasters are said to be the origin of BCP. Recovery from disasters is a concept started primarily in the USA in the 1950s when companies stored backup documents and electronic data on alternate sites. When the simultaneous terror attack took place on September 11, 2001, in the USA, financial institutions moved to their alternate offices to continue trading, and their minimizing of the loss from business interruption caught the eyes of the world. This incident caused the spread of BCP as total plans for business continuation.

Later in the USA, after the devastation by hurricane Katrina, “Implementing Recommendations of the 9/11 Commission Act of 2007” (Public Law 110-53 2011) was approved in the Congress in August of 2007. Based on Title IX “Private Sector Preparedness” of this act, the “voluntary private sector preparedness accreditation and certification program” was established with the Department of Homeland Security being the primary government department. The program encourages private businesses to establish voluntary disaster measures with the government setting the certification standards.

16.3.3 BCPs in Japan and Their Future

Companies in Japan have been hit by a number of crises in the past. They were the 1995 Great Hanshin Awaji earthquake, the 2003 spread of SARS that started from Guangdong in China, the 2007 Chuetsu offshore earthquake, the 2008 outbreak of avian influenza (H5N1), and so on. Ministries and agencies in Japan have shown the guideline and encouraged companies to set their BCPs and start applying them. Guidelines for natural disasters like earthquakes have been published by the Central Disaster Prevention Council of the Cabinet Office in 2005 (first edition) and 2009 (second edition). An English version of “Business Continuity Guidelines – Strategies and Responses for Surviving Critical Incidents – Third Edition” (Cabinet Office 2013) is now available. For infectious pandemics, MHLW has published “Guideline for Pandemic Influenza Preparedness at Business Entities and Establishments” in 2007 and for interruption of information communication. The METI published “Guidelines on Formulating and Implementing BCPs” in 2005 as an appendix to “Report: Information Security Governance at Corporations.” For small- to mid-sized corporations, the Small and Medium Enterprise Agency published “Guidelines on Formulating and Implementing BCPs for Small and Medium Enterprises (METI 2005).”

Large corporations in Japan are carrying out leading efforts in implementing BCPs. According to “Survey of Corporate Implementation of Measures for Business Continuity and Disaster Prevention in 2015” (2016) by the Cabinet Office, 60.4% of large corporations answered they have set their BCP plans, whereas only 29.9% of small- to mid-sized companies responded they have. Reasons for BCP plans not spreading into small- to mid-sized companies are their lack of resources to spare in preparing against natural disasters and probably the business owners’ low level of consciousness about disaster prevention.

16.4 Market Economy-Based Disaster Management Activities

16.4.1 Insurance System

16.4.1.1 History of Insurance Systems and Their Structure

There are two roots for what is called insurance today. One root is the maritime insurance that started in Italy in the fourteenth century when trading in the Mediterranean developed. This type has now developed into property and casualty insurance and life insurance. Those that offered this type of insurance organized what are insurance companies now. They are businesses of insurance. The other root is mutual aid against fires that started in the fifteenth-century Germany. They are now called mutual aid or social insurance. The insurance is mutual aid among the policy holders.

The insurance premium for the entire world in 2015 was JPY 304 trillion (about US$ 3 trillion) and JPY 242 trillion (about US$ 2 trillion), and their sum of JPY 546 trillion (about US$ 5 trillion) is greater than the Japanese GDP of JPY 532 trillion (about US$ 5 trillion) and was equivalent to 6.23% of the entire world GDP (Swiss Re 2016). These figures include premiums for mutual aids.

Life insurance makes payment upon death or survival of a person and property and casualty insurance upon occurrence of damage. Thus, there are a number of property and casualty insurance policies for various risks in the market. Property and casualty insurance may cover airplane accidents or large-scale plant accidents when a single accident causes a huge insurance payment with a single policy. It may also have to face huge payments upon a large natural disaster like an earthquake or typhoon for making multiple insurance payments at the same time. In other words, there is a possibility that a single insurance company cannot cover the huge insurance payment. To cope with such situations, insurance companies over the world are policyholders of reinsurance, i.e., insurance of insurance, to share risks of such cases. Such reinsurance has been around for many years. The oldest of such reinsurance contract on records is one about a cargo on a ship in 1370 (Carter 1983). Hearings with reinsurance companies, Munich Re, Swiss Re, and Lloyds, revealed that insurance companies in Japan also entered reinsurance contracts with overseas reinsurance companies since the late nineteenth century. Currently, there are 41 life insurance companies and 52 property and casualty insurance companies with licenses to operate in Japan (GIAJ 2017; LIAJ 2017).

16.4.1.2 Disaster Management Functions with Insurances

Many of us think that the function of an insurance is to make insurance payments upon outbreak of accidents, i.e., functions to recover the original state. Premium for insurance policyholders that engage in activities with large risks are naturally high.

Making use of this fact, policies over the world are leading to disaster reduction with increase in compulsory insurance premium for conducting activities that may cause damage to social properties. Forcing insurance to the business owner leads to assuring saving of the victims as well in case a damage breaks out. Also, for example, worker's compensation to cover the responsibility of business owners stated in the Labor Standards Act of Japan has its premium affected by history of accidents with the business. This policy leads to efforts by business entities to reduce work-related accidents. The total amount of worker's compensation paid in 2015 in Japan amounted to JPY 792.1 billion (about US$ 7.2 billion) (MHLW 2017).

On a separate issue, automobile liability insurance, a compulsory insurance for automobile drivers, made insurance payment of JPY 792.1 billion (about US$ 7.2 billion) in fiscal year (starting in April) 2015 (GIAJ 2017). The amount of voluntary insurance payment made for automobile caused personal injuries and property damages amounted JPY 163.7 billion (about US$ 1.5 billion) in the same fiscal year (GIROJ 2017). These insurance payments are made for the damages to the victims caused by the policyholders that caused the accidents. Without these insurances, the victims have to receive liability payments from the driver through private settlements or litigations causing high costs to the victims to receive relief. Insurance is something we cannot live without.

Furthermore, disaster management measures are subject to reviews by those investing into overseas reinsurance companies. Measures that seem questionable to the reviews would raise the premium payment for the reinsurance that covered the measures. An increase in the reinsurance premium results in an increase in the insurance premium in Japan, and the monetary incentive would correct the disaster management measures that looked questionable to the eyes of the reinsurance company investors.

16.4.2 Disaster Management Activities by Other Private Sectors

16.4.2.1 History of Disaster Management Activities by Other Private Sectors

The private sectors besides insurance companies involved with disaster management are insurance brokers, insurance agents, and risk-consulting companies affiliated with insurance companies. Insurance brokers, independently from insurance companies, have been providing advices for long years to the policyholders about disaster management. One of the broker company giants Marsh & McLennan Companies has been around since the mid-nineteenth century. Other than insurance brokers are risk-consulting companies affiliated to general construction companies or banks. New venture businesses in risk-consulting with no affiliation to insurance companies, general constructors, or banks are starting to come to existence.

16.4.2.2 Outline of Disaster Management Activities by Other Private Sectors

Giant insurance brokers today analyze damages from natural disasters with simulation models and issue risk-linked securities. The annual sales in fiscal year 2015 for the publicly listed five major insurance brokers (Marsh & McLennan, Aon, Arthur J. Gallagher & Co., Willis Tower Watson, Brown & Brown Insurance) summed to about JPY 4250 billion (about US$ 39 billion). Note that insurance brokers make their profits primarily from commission for insurance sales; thus, sales from disaster management activities make part of the JPY 4250 billion sales. Risk-consulting companies related to large corporations have been involved in consulting for disaster management activities for large private companies. On the other hand, risk-consulting ventures offer more elaborate services with adjustments based on customer locations. In any case, consulting by these private sectors will allow various users to effectively carry out disaster management activities.

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Major Insurance Brokers

Aon: http://aon.com/
Arthur J. Gallagher & Co.: http://www.ajg.com/
Brown & Brown Insurance : http://www.bbinsurance.com/
Marsh & McLennan: http://www.mmc.com/
Willis Tower Watson: http://www.willis.com/

Chapter 17
Supporting Disaster Victims

Tadahiro Motoyoshi

Abstract This chapter opens by discussing what effects disaster victims suffer from in their lifestyles and psychology. Then it will summarize what support systems are available in supporting victims that suffered large damages in terms of legal systems, public support, and psychological caretaking. The chapter closes with discussions on life and psychological effects of those that suddenly 1 day turned into crime victims and various supports for them.

Keywords Disaster relief · Disaster victims · Legal system · Psychological recovery · PTSD · Reconstructing livelihood · Victim support

17.1 Suffering Damages

A large number of lives have been lost with natural disasters in Japan. This section reviews problems about disaster victims.

17.1.1 Effects on Disaster Victims

When we are faced with natural disasters, the most important thing is to protect our own lives. We tend to apply the word "disaster victims" to mean those that suffered from a disaster but managed to survive it; however, we must not forget the many victims that lost their lives for the event. We would like to reconfirm that saving lives has the highest priority at the time of disaster.

Victims that survived a disaster, however, have a number of hardships waiting for them. Under the situation of being unsure of what effects the strong blast caused to

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their bodies, the lifelines stop immediately after the disaster, and they have to face a number of hardships under the lack of supplies and information. Kimura (2007) defined four phases of post-disaster situations that the victims have to go through.

The first 10 h is the "disorientation" where no one in the disaster-hit area is sure what is happening and not sure what action to take. Systematic disaster response by public organizations like local governments, the fire department, nor the police have not started, and the victims have to survive the disaster on their own. During this time immediately after a disaster, self-sustaining actions are most important. To minimize confusion in our lives and to keep our minds in peace, we shall plan beforehand what situations we will face during the disorientation period and plan preparations to overcome the difficulties.

After several hours are past since the point of disaster outbreak, the victims can grasp what happened to themselves and start mutual support actions like lifesaving, rescue, and safety confirmation activities. This is when the "Acceptance of New Reality," totally different from ordinary societies, takes shape. With recent disasters, public organizations like self-defense force, police, and fire department start systematic disaster response in stages as early as possible; however, for wide-area disasters, such public responses take time.

Still within days after the breakout of a disaster, building and roads are still destroyed, and lifelines of gas, water, and electricity are still unavailable. In case of wide-area disasters, communication infrastructure takes long time to recover, information supplies are short, and many disaster victims are forced to live in evacuation shelters. People under these circumstances help each other to survive the inconvenient living conditions irrespective of their social status or jobs, and this time is called "disaster utopia."

When the social infrastructures like lifelines are recovered and the societies gradually regain calmness, people start on the road to "Reentry to Everyday Life." They have to overcome their griefs and hardships to reconstruct their lives although it may take very long times. Some of the disaster victims, however, find their directions and paths to recovery and reconstruction and quickly rebuild their lives. The power to recover relatively but smoothly from disasters is called "disaster resilience," and it is catching attention these days. They depend on public support for their recovery and reconstruction. For faster recovery and reconstruction, the societies need enhanced individual resilience as well as resilience of the whole society.

17.1.2 Effects on the Psychology of Disaster Victims

Immediately after being hit by disasters, we sometime encounter effects to the body like, headache, stomach pain, loss of appetite, or worsening of chronic diseases. We may also face mind or psychological effects like anxiety, fear, irritation, or loss of interest. Adults may find effects on their habits like increased alcohol consumption or smoking and, in case of children, maybe degenerative behavior. These are normal reactions for people faced with abnormal conditions and are called "normal stress reactions." We need to understand that anyone can experience normal stress reactions after receiving some shocks, and they are not behaviors to be alarmed about. Many people with normal stress reactions gradually return to their states before the shocks as time passes by.

Some people, however, if they suffer traumatic events like serious injury that almost took their lives, may continue to suffer from the stress reactions for long times, and their psychological pain may prevent them from returning to their social and occupational activities. These symptoms are called "post-traumatic stress disorder (PTSD)." Typical symptoms of PTSD are sudden and repeated dreams or flashback of the traumatic event, being not able to have positive sensation of happiness or love, dissociative disorder for no reason, avoidance symptoms of the traumatic event, sleeping disorder, turning hostile, or arousal symptoms like excessive wariness or startle reaction. If the pain makes it difficult to lead regular daily lives, the advice for the victim is to consult with a doctor or counselor.

17.2 Systems for Victim Support

Disaster victims are subject to a number of effects on their lives, and their minds, however, still have to recover their lives before the event. Systems to support disaster victims in their efforts for recovery have gone through improvements throughout the history of disasters. This section summarizes systems for supporting disaster victims in Japan in three categories of law, public systems, and caring for the mind.

17.2.1 Legal Systems to Support Disaster Victims in Japan

When a natural disaster strikes, we lose a number of foundations for our lives and enter a state where our fundamental rights assured by the constitution are damaged. Rearrangement of legal systems, therefore, is on the way to support disaster victims.

Disaster Relief Act (1947) is the oldest of them all set in 1947 after the 1946 Nankai earthquake. Article 1 of the law states that "The purpose of this Law is to protect victims of disaster and maintain social order by causing the central government to provide needed relief services on an emergency basis in cooperation with local government and the Japan Red Cross, other entities, and the people of Japan." That means for disaster victims with difficulties in maintaining their livings immediately after the breakout of a disaster, the central government provides emergency rescue and protection as necessary. The rescue involves setting evacuation shelters or temporary housing; emergency repair of houses; food preparation and supply of food and drinking water; providing school supplies, clothes, and beddings; medical and maternity services; search for corpses and their disposition; burying; and removal of obstacles like rocks and mud near housings. The Great East Japan earthquake revealed new problems of deemed temporary housing, wide-area evacuees, former residents in the difficult-to-return zone, and welfare evacuation shelters. Systems of rescue and protection responses immediately after a disaster need flexibility in their applications.

The 1995 Great Hanshin Awaji earthquake triggered the setting of Act Concerning Support for Reconstructing Livelihoods of Disaster Victims (1998). After its amendment in 2007, the purpose of act is to support the reconstruction of livelihoods of persons who have suffered substantial damage to the foundations of their livelihoods due to natural disasters, by providing measures to pay them support grants for reconstructing their livelihoods with the use of funds contributed by prefectures from the perspective of mutual support and thereby helping stabilizing livelihoods of residents and promoting the prompt recovery of affected areas. Households whose housing units have been totally destroyed or suffered large damage will receive support grants. The 1973 Act on Provision of Disaster Condolence Grant, set after the 1967 Niigata Uetsu flooding, states that it grants disaster condolence money to family members of the deceased or consolation money for serious disaster injuries. Victims that suffered damage to their housing units or property can receive loan necessary for rebuilding their livings as disaster support fund.

17.2.2 Public Systems to Support Disaster Victims in Japan

There are also a number of public systems to support disaster victims. Loan System for Life Welfare Fund loans necessary expenses for rebuilding livings for low-income households with difficulty in setting loans with banks or households with disabled or care receivers. There is also a system for single-parent households, i.e., single mother widows or single father widowers, welfare fund loans to support their independence, and special measures will be taken for disaster victims to delay their return of loans.

In terms of supporting child education, the kindergarten attendance promotion program reduces the entrance and attendance fee depending on the guardian's income. There are also systems for free textbooks (school textbooks in Japan are usually purchased at fee) or discount or exempt tuition for children, students, or their guardians in elementary, middle, high school, or special needs schools. Most universities also offer tuition discount, emergency scholarship, or student loans.

In terms of jobs, there are systems for reimbursement of unpaid salary from bankrupt companies, unemployment benefits payment from employment insurance, free job training, and support system for living during training periods. Also, there are special reduction of local tax and national tax, discount or exemption from medical and nursing insurance fee, public fees, facility usage fees, nursing fees, and exemption from NHK reception fee for a certain period.

As we saw above, there are a number of various systems to support disaster victims; however, most people learn about them for the first time after they suffer from disasters, and there are even cases when the information about them do not reach the disaster victims. Sometimes new systems are set after occurrence of disasters. At the time of a disaster, specific and useful information supports the disaster victims, and administrative consulting is needed to quickly deliver such information to disaster victims so they can make use of the systems for rebuilding their lives.

17.2.3 Caring for the Minds in Disaster Victim Support

Disaster victims, immediately after the disaster, suffer normal stress reactions of feeling anxiety, having hard time sleeping, losing appetite, being irritated, and losing motivation to do anything. A way to support disaster victims immediately after the strike is psychological first aid (PFA) (National Child Traumatic Stress Network and National Center for PTSD: NCTSN/NCPTSD 2006). PFA is a method, based on researches so far on trauma recovery, which collected effective caretaking practices in reducing psychological pain for disaster victims with consideration to life stages and cultural factors. Application of PFA first secures safety for the disaster victims, watches them without pushing support services upon them, and provides practical specific supports and information to them.

After supporting the disaster victims with PFA, it is the turn for Skills for Psychological Recovery (SPR) (NCTSN/NCPTSD 2010). SPR is a training to lessen pain for the disaster victims and support them in gaining skills to cope with the number of difficulties they face like post-disaster stress. The purpose is for the disaster victim to gain self-confidence in recovery from the disaster. SPR emphasizes supporting forward moving actions through worksheet exercises to enhance the problem-solving skills.

PFA and SPR are not well shared among the people that actually carry out support activities in disaster-struck areas. PFA and SPR aim at supporting the disaster victims to stand on their own without putting pressure on them or pushing support service on them. Support without imposing it is the key, and we need to spread support activities that follow guidelines of support activities.

17.3 Being a Victim

17.3.1 Effects on Disaster Victims

Systems for supporting natural disaster victims and their psychology are immature; however, with the history of disasters, a number of support practices are shaping up. In comparison, systems for supporting victims of crimes and airplane and railway accidents still have shallow history. Crime victims, 1 day out of the blue, suffer death, injury, or property loss from crimes like manslaughter, violence, sex crime, child abuse, or drunk-driving. Victims of airplane or railway accidents suddenly encounter the accident and suffer death or bodily injury.

Victim Support Center of Tokyo (2007) reported on its study of family members of criminal victims that they are burdened with medical, transportation, and court expenses; lose sufficient time to perform housework, child care, or nursing; enter financial difficulty from retiring or taking leave of absence from work because of the incident; and forced to relocate to avoid curious eyes from the neighbors. Their daily lives suffer great influences from the crime. They also suffer large mental shocks that their family member was a crime victim, and sleeping disorder and loss of appetite persist over a long time. Many are forced to receive medical treatment for the stress symptoms, sufferings that are especially frequent with female family members. Family members of the victim not only have lost their irreplaceable family member, but they have their lifetime plans totally turned over from the bottom. Mental suffering is also extremely significant with their lives facing overall changes, and they are forced down to the bottom of grief and pain. They also often feel anxiety, burden, and pain with questioning from the police and prosecutor, testimonies in court, and discussions with the lawyer. In some cases, interviews from the mass media ignore privacy and sometimes cause confusion. The suffering is not just direct from the crime, but family members are drawn into a number of events to suffer secondary damages. The report pointed out that about 90% of family members of criminal victims answered they suffered secondary damages and that we need to have social understanding for criminal victims and their family members.

17.3.2 Legal Systems for Supporting Criminal Victims in Japan

A legal system for supporting crime victims is the Benefit System for Crime Victims, set after the 1974 bombing of the Mitsubishi Building, Tokyo. The system intends to mitigate the financial damages with benefit payments from the central government to family members and victims who suffered death or serious injury by intended crimes like random attacking and have no hope for receiving any compensation. The system went into effect in 1981 and is said to be the first policy to support criminal victims. This system of mere financial support does not make much effect for a long time, and in the meantime, private activities to place first priority on human rights of the victims turned active. After the 1995 Tokyo subway sarin attack, National Police Agency established Office for Crime Victims in 1996. In 1998, a number of organizations that were active in providing criminal victim support over the nation formed National Network for Victim Support. As criminal victims voiced their call for comprehensive support, the central government, at last, started to take measures for protecting rights and benefits of criminal victims. The measure, Promotion of Policies for Crime Victims, involves recovery or mitigation of damages the crime victims or their family members suffered and support them so they can recover their calm lives. It also calls for the victims and family members' proper participation into the criminal case processing. In year 2004, when the trial jury system started, Basic Act on Crime Victims was set. In 2008, Victim Participation System was introduced so criminal victims could take part in criminal trials. Further in March of 2011, the Cabinet Office of the Japanese government set basic plans for crime victims, and the legal system to value rights of criminal victims finally shaped up.

17.3.3 Public Systems for Criminal Victim Support in Japan

Promotion of policies for crime victims led to stationing supporting staff and hotlines for criminal victims in public prosecutor's office over the nation. These measures allow the staff in responding to consultation requests from criminal victims, guiding and escorting them to courts, helping them with procedures for case records review, or having evidence returned, i.e., the support not only covers financial conditions but also psychological aspects and life recovery processes. Victim support centers are designated by Prefectural Public Safety Commissions as private organizations to support criminal victims. Japan Legal Support Center (JLSC) also provides support for criminal victims.

In addition to the above public organizations, criminal victims are starting movements to gather and form networks for mutual support among themselves as self-supporting organizations. More supporting organizations have formed, e.g., Child Guidance Offices for response to child abuse and Spousal Violence Counseling and Support Centers and Counseling Center for Women in response to domestic violence.

The movement is not limited to criminal victims, but programs for supporting traffic accident victims and victims of public transportation accidents like airplanes or railways are taking shapes. All these programs and systems have purposes of providing information or necessary support in active manners so the victims or their family members can gather and take steps toward recovery from their deep grieves or harsh experiences.

17.3.4 Psychological Care for Supporting Victims

Victims of crimes and accidents can experience normal stress disorder. Among those with traumatic experiences, some end up with PTSD with the stress reactions not disappearing even after long times after the events. Sexual crime victims tend to develop PTSD (Kessler et al. 1995).

WHO in 2011, published "Psychological First Aid: Guide for Field Worker." This guideline explained what caregivers need to know in supporting victims, e.g., to respect the needs and intentions of the victim; to keep the response flexible to meet different needs of individual victims; to provide support to meet victim's pace, not to insist on support the victim does not want, the importance of giving specific supports to meet the situation and needs of the victim in the early stage; and to make proper intervention if the victim cannot make decisions or is facing dangers that can threaten their lives. Supporters and doctors that were actually involved in victim support based the guideline on their empirical knowledge; however, scientific evidence of what support is effective is still insufficient. Scientific research and more knowledge are crucial for the future of victim support.

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Part V
For Advancement of Societal Safety Sciences

Chapter 18
Governance and Forming Agreement for Societal Safety

Yukio Hirose

Abstract This chapter reviews problems that surround high-level radioactive waste (HLW) and discusses what the governance of societal risk is. Governing all the risks scattered throughout the society takes multidimensional evaluations of trade-offs among multiple benefits and risks, and fair decision-making is essential for reaching agreements among members of the society on risk governance.

Keywords Agreement formation · Ignorance · NIMBY · Risk governance · Risk trade-off

18.1 For Governance of Societal Risk

18.1.1 What Is Risk Governance?

One of the purposes of Societal Safety Sciences is to study how to reduce risk. For its safety and security, our society has to take on reducing risks that are present here and there within. For identifying, analyzing, evaluating countermeasures, and properly performing tasks at each stage, scientists, governments, the industrial sector, and citizens have to complete their roles. Renn (2008) reported the necessity of cooperation among public and private actors in managing risks related to them for risk governance, i.e., the society to control risks. Societal risk governance means for each stage of societal risk control, the society selects proper members to perform the tasks; therefore, it requires agreement with trust and faith on which organizations and individuals assume the role of risk control.

This book, so far, explained how the society properly performs analysis, countermeasures, and evaluation of risks based on agreements by the whole society at times. The book, however, also revealed cases when the society failed

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to share common understanding of analysis, evaluation, and control for risk governance due to reasons like uncertainty and complexity of risks themselves or conflict of interest and different sense of values among the society members. Typical examples of the latter are the problems of global warming and handling high-level radioactive waste (HLW).

18.1.2 HLW in Need of Governance

There are about 400 nuclear reactors in the world. Brunnengräber et al. (2015) pointed out that spent HLW so far sums to 270,000 tons and is increasing at a rate of 100 double-deck buses annually. Most of HLW are stored within nuclear power generation facilities or storage plants; however, proper processing of them for permanent disposition is an urgent issue to solve because of possible risks of radioactive contamination caused by terror attacks or natural disasters. It takes several tens of thousands of years for HLW to decay to safe levels. The most desirable risk control, currently, is to bury them to depths of several hundreds of meters.

Governance about deep geological HLW repositories involves a number of problems including extremely long-term risk analysis of HLW, evaluation of effect, and reliability in technologies for underground burying, checking the economic effect in estimating the cost, and dealing with uncertainty. We also have to face the ethical issue of passing down the negative legacy of HLW to the future generation in turn for gaining the convenience of nuclear energy. One of the factors that make risk governance of HLW extremely difficult is that the residents in the area to build risky facilities often develop the attitude called "not in my backyard (NIMBY)" that they think building such facilities near where they live is troublesome although they recognize the social needs for them. In fact, regions near the sites to build final underground-burying facilities have to carry the burden of direct risk and harmful rumors of HLW and other accompanying risks to the stigma. An overall social agreement is hard to reach because people would rather not have the final location of deep HLW repository near where they live, even though they acknowledge and agree to the overall argument of deep HLW repositories.

The needs for cooperative and step-by-step approaches between residents of the proposed site and the stakeholders are internationally recognized (NEA 2010) for forming an agreement of geological disposition of NIMBY-type risks. A cooperative approach here means opportunities for the residents in deciding whether to accept or deny the construction plans through early and frequent participation to hearings of the stakeholders' plans so they can ask questions and voice their opinions. A step-by-step approach means to prepare a number of stages in forming the agreement with ample time at each stage so the decisions are rational and adequate based on thorough discussions. Among the EU countries that apply cooperative and step-by-step approaches, none have finalized agreements about deep HLW repository locations other than Sweden and Finland.

18.2 Trade-Offs About Societal Risks

18.2.1 Dilemma with Risk Governance

One of the problems to solve for governance of societal risks is to balance out the number of risks and cost. Graham and Wiener (1995) brought people's attention to the trade-off relation of reducing one risk factor that can raise another risk with the example that banning chlorine in drinking water can lower the risk of developing cancer; however, the act can raise the risks of other water-caused infectious diseases like cholera. Wolf (2011) showed that efforts in AIDS prevention saved a large number of lives; however, allocating medical staffs to AIDS prevention programs led to shortage of personnel in other medical activities causing weakening of the entire health system in Africa with higher health risks. These cases are facing the dilemma of whether to counter a specific risk or to leave it alone so other risks do not have to increase. Another common dilemma is whether to spend on a specific risk or not to spare the expense so other risks are under control.

18.2.2 Risks and Their Trade-Offs

Graham and Wiener (1995) warn about the problem of risk trade-off that has surfaced frequently. It is a problem that reducing a target risk can give rise to new risks that conflict with the target. They categorized risk trade-offs into four types depending on whether the target and the conflicting risks are of the same nature and whether the socials groups that the risks affect are the same or not. When the same risk starts to affect another social group, it is called "risk transfer." Intergenerational risk transfer is the form of risk transfer with risk reduction for the contemporary generation causing the same risk to the future generation. Problems that we face also include risk transfer from a certain social group leading to the same risk to another group.

Risk of HLW involves the problems of risk management for the whole society pushing the risk to a specific region and of transferring the cost and risk down to future generations so the contemporary generation can avoid the risk. These problems involve ethical questions of whether risk transfer is fair or what our responsibilities are against our future generations.

18.2.3 Dilemma of Distributing Cost of Diverse Risks

Risk governance also has to solve the problem of cost distribution against diverse risks when the whole society has limited resources of cost management. Solving this problem involves political judgments of putting priorities on multiple risks. Shrader-Frechette (1991) pointed out the dilemma about conflict of social costs that spending cost on one risk management led to shortage of management costs for other risks. She claimed that solving the dilemma requires controlling societal risks to levels acceptable to the whole society.

Judging the amount of cost and level of risk control takes comparing diverse risks with common metrics. There are two common metrics: one to compare the levels of social acceptance and one to estimate the necessary costs in lowering risks to acceptable levels. First, we need a scale to compare magnitudes of risks that take different forms to evaluate the levels of risk reduction acceptable to the society. In the fields of environmental risks in Europe, the USA, and Japan, risks of death caused by environmental contamination with chemical substances have targets of 1 in 1 million. If a specific risk is present today, we have to lower its level to one accepted by the society.

For comparing costs of risk reduction, we need to calculate monetary spending in saving one life from each risk event. Wolf (2011) estimated the cost for saving a single life, i.e., the value of preventing fatality, at 1.4 million pounds in the UK. Based on this value of preventing fatality, we can evaluate whether a regulation for reducing risk is a cost-effective policy or not. In any case, how to distribute cost for management of diverse risks and what evaluation standards we base the distribution on are problems that need agreement by the whole society.

18.3 Forming Agreements for Risk Governance

18.3.1 Movement of Citizen Engagement in Public Plans

Europe and the USA have formed systems to seek citizen agreement to government policies by offering stages with citizen participation to discuss scientific technologies, policies, and regulations with societal risks. For example, Denmark is organizing consensus conferences to discuss regulations on risks that accompany introduction of scientific technologies like genetic engineering to form an agreement with all its people. EU countries have also engaged citizens into policies about deep HLW repositories as part of their cooperative and step-by-step approaches. Europe and the USA have formed a variety of citizen engagement meetings for citizen participation in determining public policies that affect the environment and health because citizen or resident oppositions had turned down more public policies and the administration offices started to lose credibility among the citizens.

More citizens, not satisfied with representative democracy leaving decisions about public plans to elected officials, these days demand direct democracy that involves citizens into decision-making or deliberative democracy that allows citizen participation into thorough discussions. Public plans that involve risk cannot win social agreement unless information is made available to the citizens early on, and public opportunities are offered to involve citizens into the discussions.

Citizen engagement in forming agreement on public plans with societal risks, however, can have disagreement not only between citizens and administrations but also disagreement among civil groups from differences in their senses of value about the environment or economics, and at times social agreements are hard to reach. For example, in trying to establish a public plan with environmental risk, some affected citizens believe the value of environmental preservation cannot be traded off with economic-based monetary compensation and, at times, the society cannot reach unanimous agreements (Skitka 2002). One reason for the difficulty in forming a social agreement is for those involved, recognizing the need to make mutual concessions is sometimes unacceptable.

18.3.2 Difficulty in NIMBY-Type Risk Governance

For public plans that involve NIMBY-type risks, the administration has to look for procedures that all social members of the affected area can accept. The procedure, in fact, is one that everyone recognizes that the selection process is fair without discrepancies and acknowledges decisions made through such procedures are reasonable results that everyone has to agree with.

When trying to develop an unbiased procedure, a method proposed by Rawls (1999) that places citizens in original positions under veil of ignorance is effective. Rawls explained that the fundamental principle for unbiased distribution of social resources takes the condition that all social members are unaware of their own individual attributes. The method creates a hypothetical condition that places a veil of ignorance on everyone, so no one knows where he stands and can accept an unbiased distribution that maximizes benefit to the most suffering.

Rawls focused on fairness in the distribution method of social resources; however, we can also apply the veil of ignorance in assuring fairness in procedures of forming agreements. Applying Rawls' veil of ignorance to selecting the location of deep HLW repository leads to the following: All members of the society, after recognizing the need for deep HLW repository for the society as a whole, acknowledge that anyone can end up living in the region that is determined as the final location of deep HLW repository. If all citizens are under the veil of ignorance that hides whether their regions can meet geological safety or economical requirements, they can start unbiased discussions about what are important as evaluation standards for deciding the final location. Selecting the region suited as the final location based on the evaluation standards that were so determined will have the citizens decide to accept the results because they had agreed that the selection process was unbiased.

Reaching an agreement about NIMBY-type risks requires proposing actual citizen engagement based on veil of ignorance followed by deliberation by the whole society.

18.3.3 For Risk Governance

Risk governance means cooperative activities by the whole society to make use of limited resources for well-balanced control of all risks scattered throughout the society.

As we discussed earlier, the problem of necessary resource distribution needed for risk management strongly affects risk governance. As we have to plan how to distribute the budget for preparations against earthquakes and global warming, we are faced with the problems of distributing cost for measures against diverse societal risks. Our budget is limited, and we, of course, have to form a balance between the cost of risk preparation and the convenience of risk reduction, but at the same time, we have to consider different evaluation standards like fairness in risk-taking and urgency in risk reduction for settling the budget distribution. Placing priority on which standard takes not just scientific evaluations, but it requires agreement by the whole society based on ethical and political judgments.

It is important that all social members share a common recognition that forming agreements about societal risks requires diverse evaluation of the trade-offs among multiple benefits and risks. In addition, governing societal risks requires all those affected to take steps beyond their own interests and agree on the procedures of making decisions that all can recognize unbiased.

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Chapter 19
For Deepening of Societal Safety Sciences

Yoshiaki Kawata

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.

Keywords Academic terms · Evolving disasters · Mega disasters · Urban disasters

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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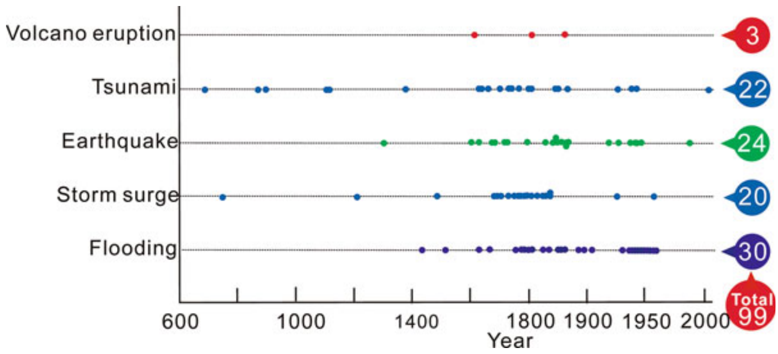

Fig. 19.1 Major natural disasters in Japan (death toll≥1000). (Source: Kawata 2015)

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

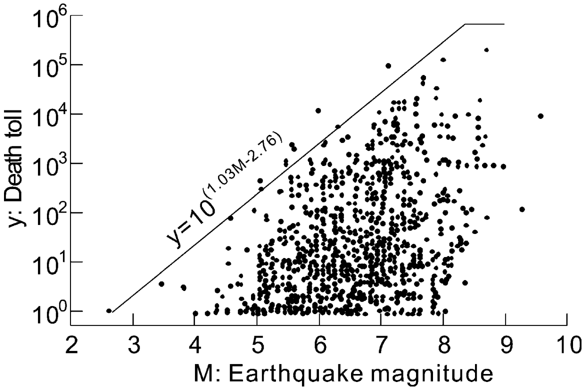

Fig. 19.2 Death tolls vs. earthquake magnitude of earthquakes in the world

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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