Disaster Risk Reduction
Methods, Approaches and Practices

Sakiko Kanbara · Rajib Shaw ·
Naonori Kato · Hiroyuki Miyazaki ·
Akira Morita *Editors*

Society 5.0, Digital Transformation and Disasters

Past, Present and Future

Springer

Disaster Risk Reduction

Methods, Approaches and Practices

Series Editor

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Disaster risk reduction is a process that leads to the safety of communities and nations. After the 2005 World Conference on Disaster Reduction, held in Kobe, Japan, the Hyogo Framework for Action (HFA) was adopted as a framework for risk reduction. The academic research and higher education in disaster risk reduction has made, and continues to make, a gradual shift from pure basic research to applied, implementation-oriented research. More emphasis is being given to multi-stakeholder collaboration and multi-disciplinary research. Emerging university networks in Asia, Europe, Africa, and the Americas have urged process-oriented research in the disaster risk reduction field. With this in mind, this new series will promote the output of action research on disaster risk reduction, which will be useful for a wide range of stakeholders including academicians, professionals, practitioners, and students and researchers in related fields. The series will focus on emerging needs in the risk reduction field, starting from climate change adaptation, urban ecosystem, coastal risk reduction, education for sustainable development, community-based practices, risk communication, and human security, among other areas. Through academic review, this series will encourage young researchers and practitioners to analyze field practices and link them to theory and policies with logic, data, and evidence. In this way, the series will emphasize evidence-based risk reduction methods, approaches, and practices.

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Preface

Japan aims to build a sustainable society for human security and well-being through the "Society 5.0" cyber-physical system. Through the creation of Society 5.0, Nippon Keidanren intends to strengthen the partnership to actively realize the UN Sustainable Development Goals of ending poverty, protecting the planet, and ensuring prosperity for all.

Society 5.0 is about leveraging the cyber-physical system, which combines the cyber and physical to maximize the use of data from both. Digital transformation is a concept that refers to efforts to transform social systems and organizational cultures through the development of new products and services, new business models, and reforms to create new value through the use of digital technology. It is important to note that it is not an end in itself.

In line with the recent discussion of the SDGs, it is important to note that the concept of human security is centered on the development model and the social science model, as it is a pathway to health at the individual, community, and organizational levels through the integration of interventions and how human security approaches address the linkages between the various causes of health threats. By examining in detail the connections between each of the targets of SDG 3 and SDGs 1, 11, and 16, which are central to the targets of the Sendai Framework for Disaster Reduction, it is possible to understand the overlap between people-centered disaster reduction and human security and well-being. This book discusses the overlap between people-centered disaster reduction and human security and well-being and the role that the disaster reduction section should play.

This book was written to propose a new interdisciplinary draft of disaster prevention that is oriented toward human security and well-being in individuals and communities, based on research and discussion by academia, including public health, public administration, and information law, surrounding nursing with the philosophy of human security. In particular, we would like to examine what a people-centered, technology-driven, and secure society is by summarizing interdisciplinary practical research activities focusing on "humans" at disaster sites.

This book is intended for students, researchers, academia, policy-makers, and development practitioners in the fields of disaster risk reduction, development

planning, public health, water resource management, urban planning, and disaster management, especially in the Asia-Pacific region. We will be happy if the readers find this book useful and relevant.

Kobe, Japan — Sakiko Kanbara
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About This Book

Advancement in science technology in recent decades in Japan and the world might have increased our capacity to tackle the adverse human consequences of various kinds of disasters and environmental issues. However, the accompanied and interlinking phenomena of urbanization, climate change, rural-to-urban migration, population decreases, and aged population have posed new challenges, especially in the small, medium-sized cities, and in rural areas of Japan. This is also enhanced with the risk of cascading, complex and systemic risk, which is defining a new normal as "living with uncertainties".

This book analyzes recent advances, trends, challenges, and potentials of Society 5.0 and its implications to different aspects of disaster risk reduction. This book is a valuable resource material for students, researchers, academia, policy-makers, and development practitioners.

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Sakiko Kanbara is a Professor in Kobe City College of Nursing. She was a Research Professor of Faculty of Nursing in University of Kochi. She is also Founder of EpiNurse Incorporated, which won the Risk Award the 2017 Global Platform for Disaster Risk Reduction. Mandated as a specially appointed Professor of Graduate School of Disaster Resilience and Governance at the University of Hyogo, Senior Research Fellow of the Psychic VR lab. She received her BS and MS in Health Science from Kobe University and her Ph.D. from the Department of Public Health and International Health, Okayama University. She earned her place as a researcher in developing new courses for global nursing and disaster nursing. She worked as an Investigator of Centre of Excellence for Disaster Nursing in Ubiquitous Society, at the Research Institute of Nursing Care for People and Community, WHO Collaboration Center for Nursing in Disasters and Health Emergency, University of Hyogo from 2006, and Professor of Doctoral Degree Program for Disaster Nursing Global Leadership at the University of Kochi, Japan from 2012, funding by MEXT, Japan. Research interests include primary healthcare, behavior science, and informatics. She received a Special Innovation Award from the Ash Center for Democratic Governance and Innovation, Harvard Kennedy School as a designer of Participatory Caring Map After Flooding in West Japan 2018.

Rajib Shaw is a Professor in the Graduate School of Media and Governance in Keio University, Japan. He is also the Senior Fellow of Institute of Global Environmental Strategies (IGES) Japan, and the Chairperson of SEEDS Asia and CWS Japan, two Japanese NGOs. He is also Co-Founder of a Delhi (India)-based social entrepreneur startup Resilience Innovation Knowledge Academy (RIKA). Earlier, he was the Executive Director of the Integrated Research on Disaster Risk (IRDR) and was a Professor in Kyoto University. His expertise includes disaster governance,

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Naonori Kato is a Researcher in KDDI Research, Inc. and an Executive Director of the Next Generation Fundamental Policy Research Institute (NFI). He is also a Visiting Associate Professor at the Open University of Japan and a part-time Lecturer at Kanagawa University. He graduated from the Faculty of Law, Niigata University in 2009 and withdrew from the 5-year doctoral course of the Department of Informatics, the Graduate University for Advanced Studies in 2014. He has excellent experience in regulatory research of personal data not only in Japan but also in the EU and the US. He was a member of the working party to translate ISO 29100 (Privacy framework) into Japanese funded by METI. He has also excellent experience in consumer analysis. He was a Researcher in National Institution of Informatics and NTT Docomo Mobile Society Research Institute. He has a Master's degree in informatics. He is also active in publishing papers and has published some journal papers and international conference papers.

Hiroyuki Miyazaki received a B.A. in environmental information from Keio University, Kanagawa, Japan, in 2006, and M.E.S. and Ph.D. degrees in environmental studies from The University of Tokyo, Japan, in 2008 and 2011, respectively. From 2011 to 2012, he was a JSPS Postdoctoral Fellow with the Center for Spatial Information Science, The University of Tokyo. Since 2012, he has been a Researcher with the Earth Observation Data Integration and Fusion Research Initiative, The University of Tokyo, as well as a Seconded at the Asian Development Bank, Philippines. In 2016, he was appointed to Project Assistant Professor with the Center for Spatial Information Science, the University of Tokyo, and was seconded to the Asian Institute of Technology, Thailand. His research interests include geospatial information science, satellite remote sensing for socioeconomics, and applications to sustainable development. Since August 2021, he has been appointed as a Technical Advisor in Global, Inc. and since June 2021 as the President to serve for R&D and HR development in space utilization, AI, and IoT.

Akira Morita graduated from Faculty of Law, University of Tokyo in1976. He worked as a Professor, Faculty of Law and Economics, Chiba University, after which as Professor at The University of Tokyo for Graduate Schools for Law and Politics, Faculty of Law and Graduate School of Public Policy, of which he was

Dean from 2004 to 2008. He was the first Director of Policy Alternatives Research Institute, University of Tokyo, from 2008 to 2010, and Senior Fellow from 2010. He also served as Chairman of Central Social Insurance Medical Council; Director of the Research and Development Center for Social Technology (RISTEX), Japan Science and Technology Agency (JST); Professor at National Institute of Population and Social Security Research; Faculty of Policy Studies, Tsuda College; and Chairman, Council on Customs, Tariffs and Foreign Exchange, Ministry of Finance from 2017. Currently, he founded Next Generation Fundamental Policy Research Institute (NFI), which researches methods for policy formation using data. He is currently the professor emeritus of University of Tokyo.

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Chapter 1
Science, Technology, and People-Centered Society

Sakiko Kanbara, Rajib Shaw, Naonori Kato, Hiroyuki Miyazaki, and Akira Morita

Abstract This chapter provides an overview of key concepts addressed in this book and highlights the key community issues faced in Japan and elsewhere before, during, and after recent major disasters. It examines what a people-centered, technology-driven, and secure society would resemble. By summarizing interdisciplinary practical research activities focusing on "human beings" at disaster sites. In particular, the research and experiences are shared from the perspectives of disaster risk reduction, public health, public administration, information, and law with nursing on the philosophy of human security and well-being. Through analyzing different field challenges and potentials in Japan and abroad, a trans-disciplinary approach to disaster risk reduction (DRR) would be recommended. We hope that the transformation process by engineers, natural scientists, and policy-makers to realize Society 5.0 will lead to disaster risk reduction as a human security component and an advancement of freedom to live with dignity for all.

Keywords Society 5.0 · Human security · Well-being · Digital transformation · Care

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1.1 Introduction

In recent decades, scientific and technological advances in Japan and abroad have enhanced our ability to cope with the adverse human impacts of various types of disasters and environmental problems. However, socio-demographic issues such as urbanization, climate change, rural–urban migration, population decline, and aging have brought new challenges to small-, medium-sized cities and rural areas in Japan and many other countries. In addition, cascading and complex systemic risks also increase and define a new common sense of "living with uncertainty."

In disaster risk reduction, the "Sendai Framework for Disaster Risk Reduction" states that priority action 1 is to "understand the risks" (United Nations 2015). Understanding the risks of vulnerability in human life and health and generating practical information to reduce those risks is essential. These procedures are becoming increasingly complex in the new risk landscape.

Many health professionals, volunteers, and community members have responded to people's lives and health hazards in unplanned and unseen settings in natural disasters and emergencies. In this context, it has often been necessary to determine on the spur of the moment what the vulnerable population is and what the long-term community resilience of the people is, to be result oriented, and to come up with innovative approaches. Researchers in human sciences, sociology, informatics, public administration, and disaster science such as safety engineering and medicine have discussed various aspects of the issue. Over the past decade, we have witnessed the benefits and gaps in the successful technological development and practice in disaster management, which has developed in Society 4.0, the so-called information society. The information and communication gap consistently lingers when we explore the causes of the human weakness called vulnerability to disasters. On the other hand, disaster responders were constantly overwhelmed by the lack of a system to manage the vast amount of overloaded data and information during the emergency. In addition, people outside the evacuation centers were not included in the information flow and were already left out.

Currently, Japan aims to build a sustainable society for human security and well-being through the "Society 5.0" cyber-physical system (Ministry of Education, Culture, Sports, Science and Technology, 2021). The Cabinet Office's Society 5.0 targets space and environment, with the following four stages depicted by merging cyber and physical systems and maximizing the use of data from both:

(1) Individual systems will become more sophisticated and connected across fields and regions.
(2) Collect appropriately, analyze, and utilize a wide variety of big data cross-sectionally, such as 3D geographic data, human behavior data, traffic data, environmental observation data, and distribution data.
(3) Provide the necessary goods and services to the necessary people, at the necessary time and in the required amount, and respond efficiently and meticulously to the various needs of society.

(4) All people can receive high-quality services and live vibrantly and comfortably regardless of the category such as age, gender, region, language. Through the creation of Society 5.0, the Nippon Keidanren (Business Council of Japan) intends to strengthen collaboration to actively realize the UN Sustainable Development Goals of ending poverty, protecting the planet, and ensuring prosperity for all (Keidanren 2019).

If Society 5.0 should be people centered, there is an opportunity to prepare value-added data and capabilities for social resilience using emerging technologies against potential future stiffening of the disaster chain and health risks that threaten health. The evolution of appropriate technologies necessary to work with individuals will provide the basis for their response to emergencies, increasing personal safety and community coping capacity. To ensure that no one is left behind, it is necessary to continue developing a sustainable communication ecology as a form of human security.

Related to these are the Guidelines for Promoting Digital Transformation (DX) (Ministry of Economy, Trade and Industry, 2018) and the "Declaration on the Creation of the World's Most Advanced Digital Nation" and the "Basic Plan for the Promotion of Public and Private Data Use (2020)".

In this context, digital transformation is a concept that refers to efforts that transform social systems and organizational culture through the provision of new products and services and the development of new business models by utilizing digital technology.

Digitization refers to converting material information into a digital format by automating existing paper processes. Digitalization refers to revamping an organization's entire business model and building better ways to serve clients and partners. On the other hand, it should be noted that Digital Transformation (DX) refers to the use of new digital technologies that create and flexibly modify new business models and is not an end in itself (Ministry of Internal Affairs and Communications, 2021). We are called upon to co-create a society that further refines the human sciences' insights, cultural competence, and flexibility while perfecting digital transformation on DRR (Fig. 1.1) along achievement of Sendai Flamework 2015–2030. The need for the humanities and social sciences to work together with the natural sciences to enhance regional resilience through regional activities seems the same as that created in the pursuit of "Human Security and Well-being."

1.2 People-Centric Process for People-Centered DRR

For the Sendai Framework for Disaster Risk Reduction (SFDRR), Priority 2: "Strengthening disaster risk governance to manage disaster risk" needs to adopt an interdisciplinary approach for decision-making and think broadly and positively. Before examining people-centered DRR, the perspective of disaster nursing is outlined. Nursing positions the human being as more than just a biological fact.

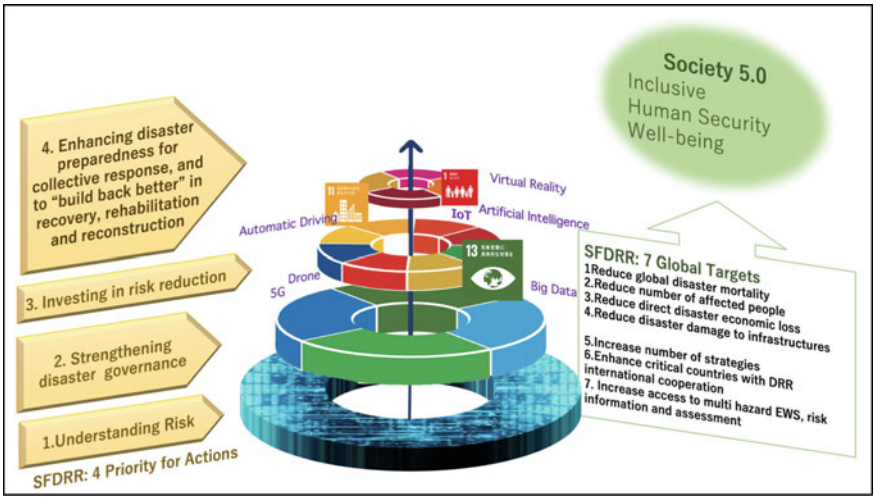

Fig. 1.1 Priority action of SFDRR and Society 5.0 with SDGs

A significant portion of the history of the concept of humanity, its practical extension, and humanitarianism has been characterized by attempts to conceptualize the nature of desirable human attributes. Nursing, which emphasizes people's dignity and life along with biological medicine, is theorized within the meta paradigms of "human," "environment," "health," and "nursing" (Donaldson and Crowley 1978). They described three disciplinary themes: (1) "Concern with the principles and laws that govern the life processes, well-being, and optimal functioning of human beings—sick or well," (2) "Concern with the patterning of human behavior in interaction with the environment in critical life situations," and (3) "Concern with the processes by which positive changes in health status are affected (p. 113)."

Residents work in seamless communities with knowledge about healthy buildings and safe societies. Also, they depend on the attitudes and cultures of their communities. There is a need to continue understanding the nature of an inclusive community, considering the various relationships across borders. The traditional family or community is no longer a standard living unit. One of the most important cultural developments is that many people live alone or in nuclear families, resulting in a society with insufficient mutual support and care. People are constantly moving, and within a given space, there are mixed cultural and social groups with varying levels of racism, gender, generational inequality, and poverty. Furthermore, cognitive neuroscience research has revealed that emotions are positioned at the top of the particular emotion hierarchy and unique to humans in recent years. It has been scientifically proven that emotions such as empathy have evolved specifically. The global indicators and benchmarks chosen to determine the status of human security reflect and reproduce a set of normative assumptions about what constitutes a "secure" human life and are becoming the scientific basis for the ideas of symbiosis and altruism.

Ethics has evolved from custom, law, ethics, and morality. This idea shows that we need a new ethical system that includes human science and technological ethics.

The International Council of Nurses' Code of Ethics affirms the human rights, integrity, and dignity of all people and ensures appropriate care for all without discrimination. Disasters, conflicts, and political divisions have increased pressure on nurses, and the COVID-19 pandemic has highlighted the difficulties nurses face. A new code will be released starting in 2021, strengthening what is outlined in the most recent code, the 2012 code. It will also promote equity and social justice; respect for the natural environment and climate; the impact of challenging unethical behavior; and the critical roles played by technology, digitized communication, and artificial intelligence in an ever-changing world. Concerning transcultural work, a new emphasis is placed on the responsibility and accountability of nurses. It has become necessary to accept personal responsibility for maintaining professional and practical knowledge while being informed about cultural values, needs, and respect. Implementation science is needed to answer how evidence can be effectively and efficiently incorporated into everyday life to improve healthcare quality (International Council of Nurses 2021).

Combining data on an individual's history and health status can achieve the following four objectives. First, it enables a more accurate understanding of the medical conditions and the application of optimal treatment methods (individual optimization of treatment). Second, collecting information on patients with specific physical characteristics makes it possible to discover and apply common symptoms and effective treatments and drugs (such as promoting medical research and developing new drugs). Third, effective and efficient allocation of limited medical resources and efficient management of medical institutions (efficient allocation of medical resources). Moreover, fourth, it can also contribute to the sustainable and efficient management of healthcare insurance finances (optimization of healthcare insurance finances).

Whether human security or the SDGs, measures should be person centered to ensure no one is left behind. Theories that ignore the need for models of human behavior and science technologies that avoid analyzing social conditions and dealing with them based on assumptions are dangerous. To further bridge the gap between theory and practice, researchers need to recognize that the impact of science and technology on policy-making is undoubtedly essential, even if it is limited and indirect. It also must be acknowledged that academic information and knowledge for the society and people are not substitutes for policy-makers' judgment in selecting policies. Still, it is also essential to make recommendations while recognizing that they are a subsidiary of people's culture and values. For this, contemporary science needs to address the fundamental question of how human beings should live. Furthermore, it needs to respond with intellectual vitality.

1.3 Digital Transformation for Science and Technology for Human Security and Social Inclusion

From the perspective of disaster nursing, considering SFDRR Priority 3: "Investing in disaster risk reduction for resilience," the key points to focus on the capacity building are (a) escaping people from disaster, (b) protecting life and health, and (c) maintaining the living environment (Kanbara 2021).

Living through a disaster means living in a recovering environment that takes months or years (Science Council of Japan 2013). The long-term and fatal effects are the sudden loss of basic livelihoods, temporary and long-term poverty and hunger, and normal health condition and well-being. Besides losing loved ones and homes, people will also lose their properties and belongings and be placed in temporary housing or alternative accommodations. Relationships (with family, friends, and community members) will be destroyed. Support networks that are important for survivors will also be destroyed. It becomes more challenging to find a new job. Losing a source of income creates a vicious cycle that makes people vulnerable to shocks. Because this can become an obstacle to preparing for life after recovery, a long-term perspective on risk reduction for people must be more critical than mere preparedness and response. During a disaster, several things suddenly become scarce. Many experiences, activities, news, and media reports have pointed out post-disaster health problems. In response to an immediate emergency, the need for medicines and health information increases dramatically.

A typical example is that the food in shelters is rich in carbohydrates but lacks other essential nutrients, resulting in unbalanced diets that later lead to health issues (Ochi 2013). On the other hand, the relief supplies provided are mostly scarce or do not reach the people reasonably enough in geography and society. The changes in people's lives outside of shelters can be described as a manifestation of their pre-disaster vulnerability.

Considering the health and survival risks of people's disasters, the medical model provides a holistic view of diseases that have been dealt with and managed by medical professionals. In contrast, the concept of human security focuses on the development model and the social science model, which are critical perspectives in a more uncertain society. Both images aim to protect the irreplaceable value of the human will to live. The human security model takes a more humane approach to disasters, allowing for potential freedoms. Practitioners of community development, such as community disaster management and public health, recognize and use disaster management as an approach to human security. However, they do not comprehensively adopt the approach because they are unfamiliar with its overall framework. In other words, the individual elements of the human security approach are not new; many of them can be found in existing health, welfare, and disaster management programs. In particular, nursing care interventions contain components of the human security approach, even if they do not necessarily use the term "human security."

It has been challenging to generate the action framework and the system for DRR in light of the global benchmark for people-centered DRR and health. Focusing

on human behavior, losses from crises have significant short-, medium-, and long-term impacts on the economy, society, health, culture, and environment. At the same, human characteristics are not generally diagnosed positively or negatively, normal or abnormal, but are distributed continuously over many gradations, including gender. Instead of helping each other in a community, these people have come to help each other as "consumers" in a global virtual society or local mass gatherings. "Human" and their normative assumptions about humanity for a living have always changed over time. It has been typed by high-level government discussions associated with inclusion and exclusion processes. The classical notion of categorization has dominated typological thinking. A concept denotes an appropriate set of necessary and sufficient attributes to define a category. These defined attributes must be present in any case, giving the category an "all or nothing" character. Lessons have been learned by accumulating success and failure data on how people coped with the situation, managed their medical resources, and provided medical care. Nevertheless, these people's problems may not have been solved because the system was designed so that each department had no choice but to obtain statistical data in a cross-sectional manner instead of flowing dynamic, people-centered data vertically in time and space.

Personal data can only be utilized to improve healthcare quality and contribute to the development of human security. In Japan, nonetheless, how personal information is protected hinders its effective utilization. The Act on the Protection of Personal Information stipulates that access to personal information is allowed without consent "when it is necessary for the protection of the life, body, or property of an individual" or "when it is vital for improving public health or promoting the sound growth of children," and "when it is difficult to obtain the consent of the individual" (Article 17). Also, in research, the Next-Generation Medical Infrastructure Act stipulates that medical data may be used if it is anonymously processed so that an authorized entity cannot completely recover the data. However, it is difficult to determine the necessity of such consent in the field, and the current anonymization method makes longitudinal data comparison and analysis difficult. Therefore, it is necessary to clarify how information should be processed for research purposes to maximize the use of medical data and extract its value.

1.4 Human Security and Well-Being on SDG3: Health and Well-Being for All

Priority 4 of the SFDRR is "Enhancing Disaster Preparedness for Effective Response" and "Build Back Better in Recovery, Rehabilitation, and Reconstruction." It is essential to emphasize the linkages between people-centered DRR, human security, and well-being.

In conjunction with the recent Sustainable Development Goals (SDGs) discussions, how human security approaches can address the linkages between different

causes of disaster threats and how interventions can be integrated to build and sustain local resilience are being considered (Kanbara and Shaw 2021).

Well-being is included in health in the first place and is also mentioned in SDG 3: "Ensure healthy lives and promote well-being for all ages." The importance of health as a core aspect of disaster management is clarified in the Sendai Framework for Disaster Reduction. Improving the overall health of communities is an essential component of resilience. SDG 3 is to be done through universal health coverage. To this end, a detailed examination of the linkages between the targets of SDG 3 and SDGs 1, 11, and 16, which are central to the SFDRR, can confirm that human security can lead to health improvements on a larger scale.

Health is defined as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." Well-being is a concept that refers to physical, mental, and social health. There is no definitive translation, but the term describes a multifaceted state, such as having a satisfying life, being happy, and being fulfilled. The term well-being was first coined in 1946 in the World Health Organization (WHO) charter, when one of its founders, Zemin Zeh, advocated the importance of health promotion and preventive medicine (prevention and treatment of diseases). This advocation is because health promotion is not only the responsibility of medical institutions but extends beyond healthy lifestyles to well-being in this context. Health is an essential aspect of human security because it is "vital and instrumental to human survival, livelihood, and dignity" (OHCHR 2008).

In recent years, in its new education framework, Education 2030, the OECD has clearly stated that "value should be placed on all humankind's prosperity, sustainability, and well-being. Education should focus on these issues. It also points to the importance of material resources and equitable access to education, safety, the environment, and social participation for both individual and collective well-being. Google (2018) has also identified the need to balance technology and life and reap its benefits without being at the mercy of technology with its "We advocate 'digital well-being'" initiative.

It is impossible to protect or control people from disease risk or disaster risk while following all the guidelines developed for managing a single disease or disaster event in the lives of individuals with multiple disorders and dangers at every developmental stage of life. New risks from damage occur faster than the vulnerabilities improve. It is tough to determine who will be affected and who will receive assistance. To support the recovery and reconstruction of local communities, establishing a system to exchange information on where medical care is needed, the recovery status of shelters and hospitals, and the demand for daily necessities is essential. Future disaster preparedness will require interdisciplinary teams to make consistent decisions based on forecasts and information to maximize survivors.

1.5 About the Book

Identifying and implementing professionally innovative technologies and new ways of organizing is not the last bottleneck but the beginning of adaptation for people. Policy-makers, administrators, professionals, and community members all confront and adapt to the challenges whenever they try to put innovative technologies into practice. Introducing new thinking, acting, and organizing living systems must be considered. To understand implementation and integration, we need to look at the dynamic process of integrating innovations into daily operations. For technology to ensure human security, living conditions and care for all need to be recognized and accepted as a collective obligation. It needs to be introduced as a civilization and legitimized into our culture. How to use the technologies we have created for individuals, communities, and systems to affect behavior change and health, and how to ensure the safety of people on time by using the results of interventions and implementation of concern, adaptation, and sustainability will be the greatest challenge for the future disaster management. This book comprises 13 chapters to remember these lessons, covering examples from Japan, the US, China, and India. The topic spreads from public health, human security, systemic risk, evidence-based decision-making, smart cities, personal life records, VR-XR (virtual reality), open governance, technology ecosystem, and *jugaad* innovation (improvised solutions). Figure 1.1 shows the overall concept of the book.

Chapter 2 focuses on science, technology, evolution, and SFDRR linkages/science; technology has contributed to advancing disaster risk reduction approaches and saving people's lives and properties. However, its nature, role, and usage have changed over time. Sendai Framework for Disaster Risk Reduction (SFDRR) focused on the increasing use of science and technology by scientists and stakeholders from governments to non-government organizations and private sectors. In the increasing multiple hazard and risk scenario, it is crucial to rethink the role of science, technology, and innovation. While science and technology aimed to find causes and provide solutions in the earlier days, one of the recent trends has been co-designing solutions with communities and other stakeholders. With the advancement of emerging technologies and in the regime of Society 5.0, we envisage that science and technology would provide customized and personalized solutions to people in the affected or at-risk communities.

Chapter 3 focuses on systemic risks and a system-based approach. In recent years, the number of disasters has increased, and their forms have become more diverse and complex. In order to cope with such disasters and minimize social damage, it is necessary to focus on the affected social functions rather than on each type of disaster for minimizing the damage and speeding up the recovery process. For this aim, it is necessary to establish an efficient matching mechanism between increasing disaster needs and limited supply capacity, using recent digital technology to achieve optimal resource allocation under uncertainty. Although response methods differ depending on the stage of the disaster, the basic idea is to share accurate information. It is essential to accumulate information that can be utilized in a disaster. In this chapter,

as specific examples of utilizing such information, we demonstrate how to increase resilience in a disaster by clarifying the interdependence of urban seal infrastructure and how to utilize the "My Number" system to respond effectively to the disaster victims after a disaster.

Chapter 4 focuses on emerging issues and Japanese milestones in science and technology in DRR. Japan, over the years, has developed and used different aspects of science and technology in disaster risk reduction. There has been more emphasis on specific disciplines dominating than others, which has seen some changes through major disasters in the recent past. In the first half of this chapter, the points that need to be taken into account in information sharing and communication were extracted and described based on the experiences and observations of disasters that occurred in Japan in the Society 4.0 era. In the latter half of the chapter, it was emphasized that the first step toward such "transformation" of society as a whole begins with "observation" of the actual situation. It was shown that it is important for the sustainable resilience of a region to break down the issues and resources in the region into small pieces, and to re-create them in the local community. The realization of well-being for each individual requires a style of innovation, and the early completion of Society 5.0 requires a change of gears, the development of new technologies, and the combination of existing technologies and social systems. Continuation of diverse lifestyles of individuals through the utilization of diverse personal data is what leads to DRR.

Chapter 5 covers evidence-based policy-making for smart cities. Since around 2017, the Japanese government has been actively considering Evidence-Based Policy-Making (EBPM) to make various statistics accurate and plan and select effective policies with limited budget and resources. Using big data in planning smart cities has realized its full potential and "smartening" urban governance in specific contexts. For this purpose, "micro-geodata" is big data with location and time information and is expected to utilize for spatiotemporally detailed planning and analysis, which could not be achieved with various types of statistical data. This chapter provides some case studies on micro-geodata that created added value to governance on disaster recovery and risk reduction in Japan. It also covers one case study about a "slow city" by reducing daily life burdens by realizing a "super city" using the latest digital technology. It would suggest that differentiated strategies should be employed for improving governance processes and handling related urban problems.

Chapter 6 focuses on the importance of personal information in disasters, which has long been pointed out. There have been discussions based on the necessity of each situation, such as preparing a list of persons requiring support as an advance response, issuing disaster victim certificates, and publicizing missing persons and dead persons, but no systematic approach has been taken. However, in the wake of a series of natural disasters, numerous issues have been raised concerning the issue of personal information. The information infrastructure that utilizes the data is necessary for better use, so that AI and machine learning could collect enough data. It is also crucial to establish institutions for data usage. This chapter summarized the fieldwork and case study targeting the flood disaster that occurred in the Mabi District of Kurashiki City, Okayama Prefecture, on July 7, 2018, using personal information

as an approach and its successor work. Meanwhile, the European Commission has floated the idea of "data altruism" as it considers data governance legislation. The new idea throws a stone at traditional data protection, and it also has implications for the use of personal information in disaster prevention. In this chapter, the most serious problems of personal information use in the field of disaster prevention are identified, and the introduction of the concept of data altruism is proposed as a solution.

Chapter 7 focuses on digital transformation, information and community technology (ICT), and DRR. As the concept of Society 5.0 evolved over the last 4–5 years, it will be important to analyze the key policy perspectives of the concept and its relation to developing intelligent and resilient communities. While health care, agriculture, and education are strong pillars, disaster risk reduction and addressing critical social issues are also integral parts of the concept as a people-centered approach, which will be analyzed and highlighted in the chapter.

Chapter 8 identifies the issues in daily use and emergency training after a disaster. It explores the research and education needed from lessons learned from the catastrophe, compilation of existing research, and interviews with relevant stakeholders. In disaster prevention, combined education, planning, and training methods have been developed in GIS (geographic information system) and VR (virtual reality). Even if they have no experience in XR but have local intelligence, they can experience the spatial environment in an immersive way after checking damage information. The results can be stored as data and used to make decisions from a perspective to protect their lives and health during a disaster. The results can be stored as data and used to make decisions from a stand to preserve their lives and health during a disaster. If the results are accumulated as data and made available for secondary use as standardized indicators, it will contribute to various preventive measures. In the future, it will be necessary to consider a platform that considers the characteristics of disaster situations and the type of data, analysis methods, and destinations.

Chapter 9 covers open governance and disaster risk reduction. Against the growing frequency and intensity of disasters worldwide and the pressing planetary and socioeconomic challenges, the close alignment of scientific efforts with societal needs is imperative to ensure that science truly benefits the people. In that context, the notion of open science is gaining increasing prominence by emphasizing making the entire scientific process more open, accessible, efficient, democratic, and transparent. Due to its importance, UNESCO has also been promoting open science and open data policy over the past few years, yet there is a lack of shared values and actions for realizing open governance. This chapter establishes a broader understanding of open science and open data initiatives to bridge this gap in the context of disaster risk reduction and governance. Through the review of existing literature, four specific cases of open governance are discussed: (1) Urban Drought Management in Cape Town, South Africa, (2) Urban Flood Mitigation in Ngaoundéré City, Cameron, (3) Typhoon Haiyan in the Philippines, and (4) Hurricane Sandy in the United States. This chapter synthesizes the key lessons learned from these cases and discusses emerging trends, existing challenges, and opportunities for enhancing open governance in disaster risk reduction.

Chapter 10 gives an overview of open governance in the USA. This chapter focuses on (1) communicating and interacting with the public, (2) improving decision-making at the community level, and (3) improving collaboration among governments and government agencies. At its best, open governance improves government performance and empowers residents in disaster situations. For successful enforcement, however, open governance must include sufficient local capacity to acquire, input, and use shared data, and enhance accountability along with performance. The social media environment that enables more openness and collaboration can also spreads rumor and misinformation. Emergency managers and others in disaster situations will need to address misinformation directly. This chapter reviews the literature on open governance and disasters. It compares three cases of the use of open governance technology in the United States to provide recommendations for improving transparency and accountability.

Chapter 11 provides a technology landscape in post-COVID-19 China. COVID-19 has made differential impacts on countries and communities around the world. China, where the COVID-19 was supposed to originate, has utilized/used/developed different technologies to address the pandemic risks. Over the last 1.5 years, there has been tremendous development in various kinds of technologies, traditionally and disruptively. Also, there were many innovations in applying technologies in different contexts during the pandemic and post-pandemic recovery and preparedness aspects. This chapter will cover some of these technological developments and their governance mechanism to develop a technology and innovation ecosystem in the post-COVID-19 context in China.

Chapter 12 covers the Jugaad innovation of India, an approach to providing improvised solutions. *Jugaad originates* from the Indian language of Hindi, which vaguely means the courageous act of improvising an efficient solution with the limited possible resources to overcome the harsh constraints. Often considered a rough, informal innovation, Jugaad helps address social problems and blends seamlessly with the Sustainable Development Goals and the Society 5.0. This chapter looks at Jugaad from an innovation perspective, taking the entrepreneurial lens of Jugaad through the Bricolage Theory of Entrepreneurship. Five independent cases were selected for this study to showcase the behavior of jugaad innovations in solving a social problem and the process of the jugaad, which has become a core value of the firm. These cases are selected based on purposive sampling. The National Innovation Foundation, Government of India, the selected cases were recognized in their initiative to enhance grassroots technology breakthroughs and excellent traditional knowledge. The cases address the Sustainable Development Goal-12 Responsible Consumption and Production and analyze how the innovations address Society 5.0. Including the usage of resources, people-centric societies, merging of cyber and physical spaces, and knowledge-intensive institutional structures that can enable scalability of Jugaad innovations and sustainability of Jugaad innovations.

Finally, Chap. 13 summarizes different aspects of the book. This book revolves around a "people"-centered approach connected to a technology-driven society. This chapter presents key challenges, lessons learned, and recommendations for combining Society 5.0 and digital transformation to create resilient communities. It

is a well-known theory that disaster risk is "vulnerable" to "hazards" themselves, such as earthquakes and floods, and can be mitigated by strengthening "coping capacities" against them. Even though disasters are inevitable, risk reduction requires knowing people's vulnerabilities and improving their coping skills. Japan's current situation in recent years and its "vulnerability" to ICT and data within the information society, Society 4.0 is reflected in this chapter as: (1) the daily flux of people due to migration and work within the country and increasing population density in certain pockets; (2) the declining human capacity to cope with environmental changes and natural disasters due to low birth rates, aging populations, and diluted community networks; (3) reliance on technological rather than social solutions; (4) different digital divide at the level; and (5) unconscious overlooking of potential risks.

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Chapter 2
Science, Technology, Innovation and Sendai Framework for Disaster Risk Reduction

Rajib Shaw and Sakiko Kanbara

Abstract Science and technology have been contributing to the advancement of disaster risk reduction approaches and saving people's lives and properties. However, its nature, role and usage have changed over time. Sendai Framework for Disaster Risk Reduction (SFDRR) had focused on the increasing use of science and technology, not only by scientists but all different stakeholders from governments to non-government organizations and private sectors. In the increasing multiple hazard and risk scenario, it is important to rethink the role of science, technology and innovation. While in the earlier days, science and technology were aiming at finding causes and providing solutions, one of the recent trends has been to co-design solutions with communities and other stakeholders. With the advancement of emerging technologies, and in the regime of Society 5.0, we envisage that science and technology would provide customized and personalized solutions to people in the affected or at-risk communities.

Keywords Multiple hazards · Complex risk landscape · Science-based problem solving · Co-designing solutions · Personalized solutions

2.1 Introduction

When the United Nations World Conference on Disaster Risk Reduction was held in 2015, the Sendai Framework for Disaster Risk Reduction (SFDRR) was formed to meet the Sustainable Development Goals (Tiernan et al. 2019). Reducing disaster risk is a significant factor of the SDGs or Sustainable Development Goals (Rahman and Fang 2019) as targeted activities all work together to strengthen the entire environment and ecosystem. These are relevant because almost all targets of SDGs could

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be or can be jeopardized by disasters. The disaster risk reduction, disaster resilience, and Sustainable Development Goals are interlinked. The document's declarations address political, cultural, economic, and social intervention and strategies (Patel et al. 2021).

Sendai Framework for Disaster Risk Reduction has four priorities, which are: (i) *Understanding disaster risk, (ii) Strengthening disaster risk governance to manage disaster risk, (iii) Investing in disaster risk reduction for resilience, and (iv) Enhancing disaster preparedness for effective response and to Build Back Better in recovery, rehabilitation, and reconstruction* (UNISDR 2016). These priorities are made to improve public awareness of community members' and stakeholders' vulnerability to risk. Rather than focusing on disaster vulnerability, SFDRR also emphasizes a human-centered approach and the potential responsibilities of many stakeholders. It advocates for cooperation and coordination between international, national, and local actors in a collective effort for promoting targeted disaster risk reduction initiatives within and across various fields of activity. A "bottom-up" approach invites relevant institutions to participate in SDGs policies, which will progress the assessment of disaster risk and the design of monitoring plans, as well as their core implementations (Busayo et al. 2020).

A wide range of actions must be taken to avoid new and minimize existing disaster risk, such as integrated structural, economic, legal, health, social, cultural/educative, environmental, technological, political/institutional measures" (UNISDR 2016). As part of the Sendai Framework's four main goals of strengthening disaster preparedness and "building back better," the Sendai Framework promotes the creation and distribution of science-based risk knowledge, methodologies, as well as instruments. Since disaster management is no longer the primary focus, science and technology will be a significant role in the SFDRR's emphasis on "managing risks." In addition, to improve the line between policy and science, existing networks and research institutions are used to carry out disaster risk reduction science and technology techniques. (UNISDR 2016).

Disaster risk reduction relies heavily on S-T or science and technology, which also requires additional development. By way of introduction, Chatterjee et al. (2015) emphasize the critical application of and use of earth observations to enhance science and technology development while implying that such technology could equally be used in the disaster risk reduction (DRR) field. Furthermore, course curricula and community-based research could be advanced through such technology. For disaster risk reduction (DRR) under the Sendai Framework, S-T influences are critical. Despite their conventional beginnings in the sciences and social sciences, humanities like geography, economics, architecture, planning, art, and culture have grown in importance to reduce the likelihood of a disaster. Even while civil engineering has historically been necessary for DRR solutions, other engineering fields like environmental or infrastructure play an increasingly important role (Shaw 2020).

The SFDRR contains numerous references to science and technology. Paragraph 36(b), for example, wishes: "academia, scientific and research entities and networks to: focus on the disaster risk factors and scenarios, including emerging disaster risks, in the medium and long term; increase research for regional, national and local

application support action by local communities and authorities; and support the interface between policy and science for decision-making" (Murray 2021).

This chapter examines the role of science and technology in decreasing disaster risk and the innovation of the Sendai Framework for Catastrophe Risk Reduction of disaster risk and losses in lives, livelihoods, and essential assets. It reviews Science, Technology, and innovations for DRR in the past 7 years since SFDRR with key case examples, looks at emerging risks and the state of S-T innovations, discusses the future direction of Science, Technology, and innovation for DRR, and concludes with recommendations.

2.2 Multiple Hazards

Over the last several years, we have observed more than one hazard occurring simultaneously, which makes the consequent risk more complex and compound in nature. Systemic risks are also another issue, where we see several systems are affected by one or more hazards. From 2020, we have seen how pandemic or the infectious disease have caused tremendous pressure on the vulnerable communities, who were already facing different types of climate change impacts. Governments at different levels, and other related stakeholders like the science and technology community, civil society, and business sectors need to work together to address the changing risk landscape (UNDRR 2019). Traditional hazard specific approaches are not working, and traditional disaster management plans need to be revised to cope with this changing risk scenario.

Worst case scenario analysis is very important in this context to develop a new governance mechanism. "Living with uncertainties" is the key new normal, where we need to focus on different aspects from governance to using technology to enhance capacities and awareness. This is known as adaptive governance where decisions need to be taken based on the changing context. Inclusive risk reduction through the whole of society approach is desirable more than ever. When we discuss compounded disasters, it means the impacts are multiplied, for example, typhoon impacts are aggravated by sea level rise, and forest fire is aggravated by heat waves and changing precipitation patterns (Pescaroli and Alexander 2018).

The East Japan Earthquake and tsunami of 2011 is a classic example of a "cascading disaster", where one hazard is triggered by the other. The earthquake triggered a tsunami, which caused the nuclear meltdown. This is also known as NaTech, or natural hazard induced technological disaster. However, a natural hazard can also induce other natural hazards like a typhoon can trigger landslide and flooding. The cause and effect relation becomes important for cascading hazards. Thus, in multiple hazard scenarios, it can be cascading, compound or complex hazards.

2.3 Complex Risk Landscape

We are living in a complex risk landscape, which is becoming even more complex day by day. In the recent Global Risk Report (2022), five environmental risks become prominent among the top 10 future risks of the world: climate action failure, extreme weather, biodiversity loss, human environmental damage and natural resource crisis. Also, three societal risks got its position in the 10 top future risks: social cohesion erosion, livelihood loss and infectious disease. This is interesting to note that infectious disease is considered as a societal risk, and this possibly reflects the nature of social issues and impacts we have seen over the past 2.5 years during the COVID-19 crisis. It is also required to note that digital inequality and cyberspace failure are also considered as two prominent risks, which have widened the disparity between countries and communities. Although we talk about the slogan "leave no one behind" in the Sustainable Development Goals (SDG) framework, however in the technology advancement we fail to address the equitable access to technology without a digital divide. Therefore, our key challenge here is to think about how the advancement of science and technology can reduce the gap between urban or rural or developed or developing countries or aged population or gender etc.

2.4 Science for Finding Causes and Providing Solutions

From the advancement of science and technology in disaster risk reduction, the key target of science and technology was to find the causes of the problem and provide solutions. This led to the development of the field of science, especially targeting specific hazards, like the mechanism of earthquakes, typhoons, landslides or tsunamis. This approach has developed significantly in the developed world, and a few countries in the world like Japan, the USA, and some European countries lead this science-based research to find the root causes. This also led to the formation of research institutes or centers either independently under the government or within the universities. Another parallel set of research was going for the search and rescue operation, where the key target of disaster management was rapid search and rescue operation until mid 1980s.

Understanding the causes is the key to problem solving, and it led to significant advancement of the hazard-based approaches in the field of disaster management. Parallel to this, the engineering field also evolved significantly to find the solutions. Japan led this field of earthquake engineering along with the USA and some other countries, while Europe like Netherland and other countries lead the flood related solutions. However, in reality, it was observed that significant losses are made in the developing countries, especially for the non-engineered buildings. That led to the development of the first guidelines for non-engineered buildings in the early 1970s by the International Association of Earthquake Engineering. It was found that it is not just engineering, but the skills of masons and local artisans are the key factors

for non-engineered buildings. And, therefore, providing simple and understandable hands-on training for the masons is important.

The dominance of physical science and engineering in the disaster management field continued until mid 1990s, until the Great Hanshin Awaji Earthquake (popularly known as Kobe earthquake) of 1995 showed the importance of social science and other disciplines in disaster management. In spite of significant advancements in earthquake engineering in Japan, still, the lives of more than 6,400 people could not be saved, and one of the reasons was that more than 70% of the death occurred in single storied wooden buildings, which are mainly occupied by aged population with relatively lower income group. The importance of social science, urban planning and economics came through the recovery programs of Kobe, and the role of science made a significant change from pure science or engineering based approach to a multi-disciplinary approach.

Although post 1995 showed multi-disciplinary approaches, but the key essence was to provide solutions to the people by the researchers and scientists. They had always an upper hand to provide solutions, even if some of the solutions may not be relevant to the local contexts, since more of the solutions were made within the boundaries of the research institutions and academic organizations, which found its own challenges in the due course.

Let us share one specific example to clarify what we mean by the above statement. In an international project related to flood risk reduction in Bangladesh, there were prescribed components of river-bank erosion hazard mapping and an early warning system for cyclone preparedness in the coastal areas. However, when we interacted with the communities, their requirements were very clear. They do not want to have the hazard maps of the river-bank erosion, rather they want us (the researcher group) to identify which specific areas will be safe for their relocation, where they can stay for at least 8 to 10 years. In a similar manner, the coastal communities understand the early warning, but they want specific information on whether the landfall of the cyclone will coincide with high tide so that it will enable them to decide when to evacuate. We often overlook or ignore the needs of the communities and try to provide "our" customized solutions, which does not match with "their" needs.

2.5 Community Research with Science Technology

Community research with science and technology is required a rethink of procedures. The analysis often begins with a request for a visualization from the end-user side through discussion. Analyst shall deliver the visualization to the decision-maker. Since there are notable differences in the time horizon for processing the data, the requirements shall be analyzed for each phase: pre-impact, post-impact, and post-impact. For example, real-time acquisition is not necessary in the pre-disaster phase. Still, the data must be processed in real-time in the post-disaster phase because the disaster situation changes rapidly. After the requirements are formulated, the available technology and human resources are examined and compared. Suppose

the available resources do not meet the requirements. In that case, the difference between the requirements and the available resources is a gap. It should be filled by new solutions involving the application of technology and the development of human capabilities.

The global initiatives like Integrated Research for Disaster Reduction (IRDR) and Future Earth had already created ideas on global frameworks and cross-sectoral collaboration. Technology is already being used internationally to enable the storage of valuable knowledge through organizational learning and cooperative memory, and to transfer practical knowledge to all stakeholders. On the other hand, due to the sophistication of each technical method, it has become difficult for a single researcher to acquire the most advanced theoretical and empirical knowledge in the field and be familiar with multiple methods. Therefore, successful collaboration often requires researchers who use different methods to work together, or for another researcher to better understand the research results of a researcher who uses a different method. What is needed for effective collaboration is for researchers to become experts in their methods, become familiar with other methods, recognize the strengths and weaknesses of each, and have a solid understanding of the substantive research results.

2.6 Science Technology for Co-Designing Solutions

The above challenges have led to the development of the concept of "co-designing" solutions. This has a customer centric approach, where we need to keep the people and communities in the central part of the process, and the designing and production process should evolve around them. The community services sector has adapted co-design to combine lived experience and professional expertise to identify and create an outcome or product. Co-design is a process oriented approach, rather than a product oriented one which we often focus on. Kameda (2009) in his classification of technology for disaster risk reduction has coined the term process technology as "…the knowhow for implementation and practice, capacity building, and the social development for knowledge ownership". This has pointed out the importance of the engagement process in developing the technology along with the stakeholders. Some of the steps for co-designing solutions include: (1) dialogue with stakeholders and end users, (2) understanding the needs and priorities, (3) co-produce the solutions, (4) testing and verifying the solutions, and (5) co-delivery of solutions. Thus, essentially, it is a process of co-design to co-produce to co-delivery of solutions.

Obviously, the process has a time context, and it is often said that the co-designing solutions take a longer time for implementation. However, thinking of the time of inventing laboratory-based solutions, and failure in specific disaster cases, it is often argued that if the solutions are co-designed from the beginning, it may be more effective. Of course, it does not mean that co-designed solutions do not fail. There would be a failure too, but the recovery process from the failure will be faster.

A few principles for co-designing solutions can be as follow: (1) *Inclusiveness:* The process needs to bring together all different sectors of communities and ensure that no one is left behind. (2) *Respectfulness:* The process needs to respect the community needs and priorities and make sure that it is based on human dignity, (3) *Participative:* The process needs to ensure the fullest participation of the stakeholders, and (4) *Outcome focused:* The process needs to think of not short-term output, rather longer-term outcomes.

2.7 Science Technology for Personalized Choices

Over the past 10 years, we have seen significant development of so called "emerging technologies", which will be "essential technologies" in the next few years. While Society 4.0 talks about the information age, Society 5.0 focuses on a smart interconnected society. Disaster 4.0 and Society 5.0 (Kanbara and Shaw 2022) see their parallel growth. Sendai framework or SDGs, when these were formulated in 2015, did not foresee the major global pandemic to happen in the next five years. Two to three years of the pandemic has made significant impacts on the whole society, and urged us to rethink the meaning of life, technology, society etc. Social innovation is considered as one of the major breakthroughs in this aspect, which saw significant advancement in the development field, as well as addressing the pandemic impacts. It is yet to see a strong impact in the disaster risk reduction field, which needs co-designing solutions. We need a proper ecosystem to generate new innovations in the field of disaster risk reduction.

The advancement of new technologies have urged us to overcome many barriers. Technology mainly serves the younger people first. Or in other words, the youth groups are the first users of many new technologies. However, it is desirable that the technology needs to break the divide, in terms of age, gender, urban rural, physically or mentally challenged people etc. We need more "personalized" solutions, rather than "one fits for all" solutions. This is and should be the new trend and challenge of technology in the disaster risk reduction field. Instead of providing a common early warning system, it needs to be customized based on the local needs. Similarly, evacuation or health related support during a disaster needs to be personalized.

We often provide one or several solutions, however, the new trend should be to provide choices, rather than one solution. We use the paradox of nutrition guide and recipe example. We think the DRR solutions in the new age should focus on a nutrition guide, where the user can take their own decision based on the requirements. Thus, we should not provide a recipe like solution, but rather need to give the users the choice to make informed decisions.

2.8 Postscript

By the time when we come to an end of SFDRR or SDGs in 2030, we will see new sets of technologies around us. All today's emerging technologies will be essential technologies by 2030. Disaster risk reduction field will see immense use for these technologies in different ways. We will also see that we are living in an uncertain world with complex risk landscapes, with new risks emerging and cascading, compound and complex emergencies are becoming the new normal. In the context, the traditional decision-making will not work, and we need strong incorporation of adaptive governance. While it is obvious that the technology regime will always be faster than the governance regime, we need new ways of decision-making, and new ways of providing choices of innovative solutions. Personalized choices of DRR solutions can be the new way of incorporating science and technology in addressing and reducing disaster risks.

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Chapter 3
Systemic Risk and System-Based Approach for Society 5.0

Akira Morita

Abstract In recent years, the number of disasters has been increasing, and their forms have become more diverse and complex. In order to cope with such disasters and minimize social damage, it is necessary to focus on the affected social functions rather than on each type of disaster to minimize the damage and speed up the recovery process. To achieve this, it is necessary to establish an efficient matching mechanism between increasing disaster needs and limited supply capacity, using recent digital technology to achieve optimal resource allocation under uncertainty. Although response methods differ depending on the stage of the disaster, the basic idea is to share accurate information, and it is essential to accumulate information that can be utilized in the event of a disaster. In this chapter, as specific examples of how such information should be utilized, we demonstrate on how to increase resilience in the event of a disaster by clarifying the interdependence of urban critical infrastructure, and how to utilize the "My Number" system to effectively respond to the needs of disaster victims after a disaster.

Keywords Systemic risk · System-based approach · All-hazard approach · Uncertainty · Resilient Governance

3.1 Introduction

In recent years, Japan has experienced a series of large-scale disasters, including flooding caused by torrential rains in June and July, followed by a huge typhoon in 2020. In 2021, the country was also hit by a series of severe typhoons that caused significant damage. In the case of Japan, we experienced the unprecedented Great East Japan Earthquake and the accident at the Fukushima Daiichi Nuclear Power Plant in 2011. Since then, earthquakes of intensity 7 have occurred in Kumamoto

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and Hokkaido, and even now, the possibility of a Tonankai earthquake and tsunami occurring and preparations for such an event are being emphasized.

Not only in Japan, but also in many other countries around the world, such large-scale disasters have been occurring on an unprecedented scale in recent years, although of different types. In 2020, there was a pandemic of coronavirus infections (COVID-19). Although there have been cases of infectious diseases in the past, the fact that it has affected the world to such an extent is a product of the era of mass movement of people by massive aircraft. COVID-19 has made significant and deep impacts in different parts of the society irrespective of the development or economic levels of the country.

In the twenty-first century, on the other hand, we have gained information technology that allows us to collect and utilize data on a massive scale that did not exist before. The widespread use of cell phones and smartphones has made it possible to track people infected with coronaviruses and provide risk information, and information on infected patients and data on the effects of treatment are immediately available to the world for use in countermeasures. However, since various activities in society depend on such information technology, it has been pointed out that cyber terrorism may cause new disasters. We are also facing new man-made disasters that have never been seen before, such as wars and major explosions. Disasters in modern society are becoming more diverse, larger, more complex, and more frequent. We need to consider how we should respond to these disasters in the future.

Disasters, no matter what the cause, can cause serious damage to the society we live in. Even though it is difficult to stop the occurrence of disasters, we need to think about what measures we should take as a society in order to predict the occurrence of disasters, minimize the damage caused by disasters, and return to normalcy as soon as possible. In recent years, there have been numerous and still growing studies on disasters. Rather than focusing on individual disasters such as earthquakes and floods, this report presents a basic concept of systemic risk in society toward Society 5.0 by examining how various disasters should be addressed from a broader perspective, and in particular, what can be achieved through the use of information technology. To this end, the approach in this chapter is based on the final report of the Council on Competitiveness-Nippon (2013) "Resilient Governance" study, which the author chaired, and addresses the basic issues of disaster preparedness, including COVID-19 infection control, in order for the author to answer these questions.

3.2 All Hazard Approach

The all-hazards approach is to focus on the social functions that will be damaged and seek ways to minimize the damage to those functions and minimize the time required for recovery as much as possible. The mainstream of disaster research to date has been to consider countermeasures based on the type of disaster, such as earthquakes or floods, and to make improvements based on lessons learned. Of course, it is essential

to consider countermeasures for each type of disaster, as the forms of occurrence and subsequent damage are different. However, a wide variety of disasters have occurred in recent years; the global spread of coronavirus infections in 2020 was a disaster beyond our imagination. Other disasters we have not experienced for a long time include human induced cyber terrorism, massive explosions at chemical plants, volcanic eruptions, and meteorite falls. It is practically impossible to come up with individual countermeasures for all of these. That is why we should come up with countermeasures that can deal with any unknown disaster, and this requires a change in thinking. In other countries, especially those under military threat, measures are taken to minimize the damage to the nation and its people and to maintain the various functions of society to the maximum extent possible, based on the assumption of the worst-case scenario.

In the event of landslides, floods, etc., physical infrastructures like roads, bridges, public facilities, and lifelines are damaged. Therefore, countermeasures need to be taken to restore them to their original functions as soon as possible after the disaster is over. In the case of a pandemic, however, although there is no damage to the physical infrastructures, the movement of people and their contact are restricted, thus limiting the operations necessary for economic activities such as logistics and sales, which are essential for maintaining the various functions of society. As a result, social functions are greatly degraded, as we experienced in the COVID-19 disaster. Furthermore, in the event of a pandemic, it would take a long time to end and the timing of the pandemic is unknown.

In addition, cyber terrorism does not damage the hardware or human operations, but it does damage the functions of information and communication, which can be considered the nervous system of modern society. Needless to point out again, in an age dependent on computers and communication networks, many of the important functions of society are paralyzed. These include the functions that support the lifelines and logistics necessary for people's daily lives, as well as medical, financial, and governmental services are compromised. Therefore, this approach aims to develop a method for rapid recovery, or resilience, so that the entire social functions can cope with any situation.

The following figure (Fig. 3.1) illustrates this approach. When a disaster occurs, as shown in the figure, social functions are degraded. This lasts for a certain period of time, after which it gradually recovers. In this case, the filled-in area represents the magnitude of social damage. The challenge is how to reduce the size of the squares in this area. The magnitude of the damage naturally depends on how the risks are managed in advance. The more we prepare for possible risks, the smaller the damage will be. After a disaster strikes, the first priority is to prevent the spread of damage and save lives, but after that, it is important to maintain the lives of those affected. Faced with a situation that they have never experienced before, many of the activities that used to function on a daily basis in society will come to a halt. For example, there will be a large number of urgent needs for rescue, such as the treatment of the injured. How to respond to these needs quickly and sufficiently will be required as a response measure.

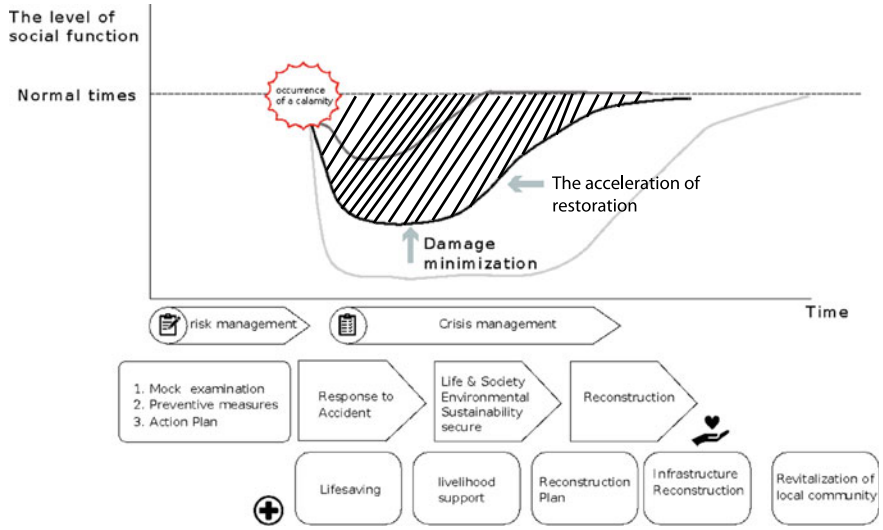

Fig. 3.1 Risk management and crisis management by time

On the other hand, the resources available to compensate for lost social functions such as rescue are often greatly reduced. Materials and services that are readily available in normal daily life, such as electricity and water, are in short supply. There will be shortages not only of goods but also of the equipment and human resources needed to provide the services. A typical example of this is medical institutions. When a disaster occurs, the number of people who need medical care increases, but the human resources of doctors, paramedics, and other medical personnel to treat those people decrease more than usual. Figure 3.2 shows a schematic representation of the relationship between needs and service supply in post-disaster medical care. Needs will increase explosively, but conversely, the supply capacity of the surplus will remain almost constant. Even if we mobilize maximum resources for the supply of surplus, there is a limit to it. In this context, the challenge is to configure the response capacity so as not to cause a "medical collapse" beyond the acceptable limit. What needs to be considered in such a situation is to quickly and accurately identify needs and detailed resources and match the two in order to efficiently use the limited social resources that are less than usual. This is precisely the challenge of information, data, and communication systems.

Whether it is a need or a resource, the first prerequisite for disaster response is to have information about the surrounding area, and then make a decision on matching the need with the resource based on that surrounding information. In order to make such decisions quickly and accurately, it is important to decide in advance what priorities should be given under certain conditions. It is not always possible to allocate resources to what is truly necessary, and bias may occur, resulting in the waste of valuable resources.

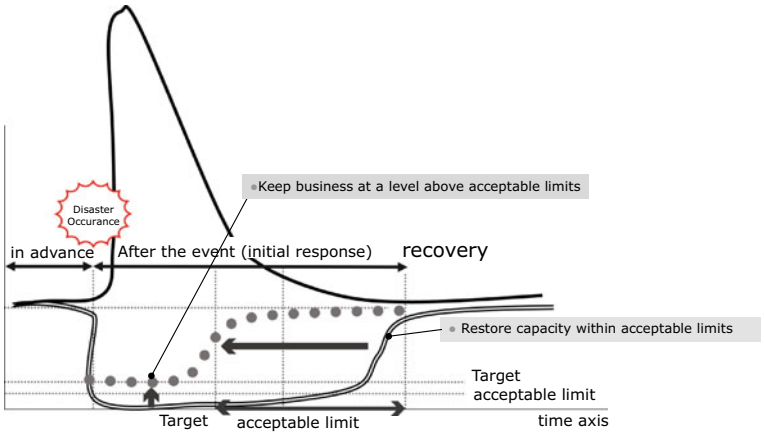

Fig. 3.2 Surge of health care needs on disaster

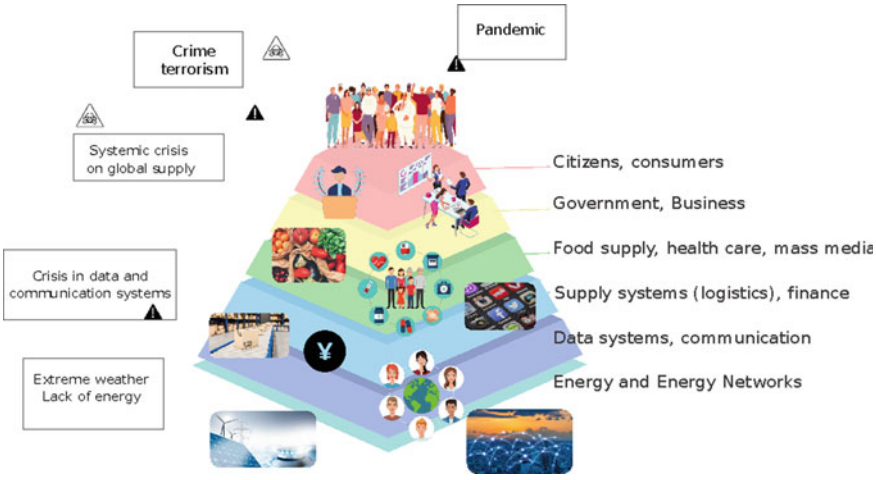

Fig. 3.3 Dependencies of social systems and factors and external threats

Figure 3.3 is based on a slide prepared by the Finnish National Emergency Management Agency in 2008. It shows what is important in an emergency, or in other words, what is most important and which elements depend on it. Since Finland is located in a cold climate, especially in high latitudes, energy and its supply system are considered the most important elements in society. Without energy, communication and logistics systems cannot operate, let alone sustain people's lives. The actual logistics and information transmission systems depend on these basic infrastructures of society. The idea behind this diagram is that only when these basic infrastructures are functioning can government activities, business, and even the lives of the people

be possible. Around this stair-step diagram are depicted various disasters that modern society may encounter.

In modern society, information is considered to be the most important element, just like energy used to be, but today's information devices cannot function without a stable supply of energy. However, today's information devices cannot function without a steady supply of energy. Therefore, according to this concept, the first thing that should be supplied to the disaster area during a disaster is energy, such as oil and electricity. In order to deliver a limited amount of medicine to where it is needed according to priority, it is necessary to convey information about the medicine, and to convey this information, energy is needed to run the equipment.

In countries where not only natural disasters but also military conflicts are expected, a basic understanding of disaster response is shared among the people even during normal times, and based on this shared understanding, drills are conducted on a daily basis to prepare for emergencies.

3.3 Methods of Disaster Response: Decision Making in the Face of Uncertainty

During a disaster, it is common for normal information networks to fail to function adequately and for people to not have access to the information they need to make accurate decisions based on their priorities. In fact, this is probably the most common situation during disasters. In the event of a disaster, rapid and accurate decision-making is required under highly uncertain circumstances. In general, rational decision-making means recognizing a clear value to be pursued and choosing the best means to maximize it. To make this possible, it is necessary to have sufficient and accurate information about the current situation and possible future situations, to have a clear understanding of the available means, and to have a shared objective function to derive the best decision.

However, in the current situation, it is almost impossible for such conditions to be met during a disaster. The situation in the affected area is not known, and the location of resources that can be mobilized for rescue is not known immediately after a disaster. Under such circumstances, there is naturally a limit to the number of appropriate judgments and decisions that can be made. After a disaster strikes, it is essential to gather information on the damage. For this purpose, it is important to have information on the age, gender, health status, etc. of the residents living in the disaster area to reduce uncertainty. At present, however, such information is not stored in a user-friendly form. Therefore, no matter how much information is gathered, the reality is that decisions must be made under uncertain circumstances.

Whether it is dispatching rescue teams, rescuing victims and guiding them to evacuation centers, providing necessary supplies, or dispatching personnel, the decisions to be made here must be based on matching the needs of each party with quality resources to meet them. The most difficult part begins with understanding the needs

of the affected people. It is difficult to gather information through normal methods, especially when the affected areas are dispersed. Measures will be taken based on the information on relief needs sent out by the affected victims, but in many cases, the severely affected victims and the affected areas do not have the capacity to send out such relief information. In such cases, the information may not reach the people who need rescue and support the most, and those people may not be able to receive relief.

It becomes a major challenge when the needs greatly exceed the supply capacity, especially on how can resources be allocated to supply areas that are severely damaged and have no demand. To do this, it is necessary to understand the normal situation in the area and estimate the damage based on that. The key to matching needs and resources is to identify needs as accurately as possible without being confused by the noise. People whose lives and societies have been severely damaged by disasters need all the help they can get, but the resources available to them are naturally limited. It is necessary to apply firm principles in order to accurately identify needs and determine the most appropriate allocation of resources. As shown in Fig. 3.2, the best way to ensure optimal resource allocation when needs greatly exceed limited resources is to establish rules for allocation based on clear priorities in advance. This is the same as the "triage" and other rules used in the medical field, where the importance of each request for assistance is determined and resources are allocated to which priority targets.

When a disaster strikes, the voices of the people on the ground can be heard as many affected areas request assistance one after another, but even if all of them are responded to, the limited resources will soon be depleted. Conflicts often arise between the disaster response headquarters and the field. This is where the contradiction between partial and total optimization arises. This problem can be alleviated if sufficient information is available to understand the situation, but in reality, conflicts are not easily resolved. For this reason, the conflict between the need for a centralized command post and the need for decentralized decision-making in the field is often discussed as a problem in the organization of disaster response. Since the ratio of decision-making bodies varies depending on the stage of the disaster, it is difficult to say which one should be used. However, if the disaster is widespread and response in the affected area is extremely difficult, the presence of a command post is essential.

Under normal circumstances, if the command center is far from the disaster area, the distance of the information route from the disaster area becomes an issue. The greater the distance, the lower the quality of the information and the greater the possibility of noise. In addition, the more relay points there are, the more organizational bias will occur, such as in the so-called "message game". Furthermore, during a disaster, a variety of peripheral information comes in from many directions. In fact, in a mock drill conducted by a certain government agency, some of the information that came in one after another by phone or e-mail was very direct, while others were so trivial that they could be ignored. Requests from big-name politicians for consideration for their constituencies are difficult to respond to, and those who repeatedly make excessive demands for priority response may not receive assistance when they really need it.

In order to overcome the problem of decision-making under such uncertainty as much as possible, it is once again necessary to establish a system for collecting and disseminating information as reliably as possible during normal times. However, on the premise that these mechanisms will not function as expected in times of disaster, it will be important to properly evaluate incoming information and make decisions based on scientific estimates for fields and domains for which we do not yet have sufficient information. The relationship between scientists (experts) and politicians (decision-makers) in decision-making under such circumstances has just been discussed in the context of measures against coronavirus infections. Although it is a difficult issue, it is important to emphasize that the prerequisite for finding the best solution depends on the quality and ratification of the information available before and after the outbreak.

3.4 Stages of Disaster Response

The meaning of information, the actors involved in decision-making, and the methods of decision-making naturally depend on the temporal stage of the disaster. There are three major stages of disaster management: (1) the life-saving stage, which is the immediate response to a disaster; (2) the livelihood support stage, which ensures the sustainability of life and social functions; and (3) the recovery stage.

(1) **Life-saving stage:** It depends on the type of disaster, but in most cases, when a disaster occurs, for example, in the case of a landslide, buildings collapse, people are trapped underneath, and there are casualties. In the case of heavy rain, some people may be buried alive in landslides. In a pandemic, the infection could spread from the first infected patient. In the immediate aftermath of such a disaster, saving lives is of utmost importance. This requires confirming the safety of the victims, rescuing the injured and moving those in danger, and controlling the spread of the disaster so as not to increase the number of victims. Minimizing the number of casualties is the primary goal of this phase.

(2) **Securing livelihood and social functions stage:** This stage can take various forms, but it is desirable to shorten this period as much as possible and move on to the stage of restoring the original life and society. After controlling the spread of the disaster and securing the livelihood of the affected people, the challenge is to maintain the lives of the affected people in evacuation centers. It is not easy to maintain a healthy and comfortable life in the deteriorated living environment of evacuation centers. Particularly in the case of a pandemic, where it is impossible to predict when the disaster will end, it is essential to supply goods and services that meet the needs of the victims in order to alleviate their anxiety and frustration. In addition, in areas where there are many elderly people, care must be taken to provide adequate health care and nursing care.

(3) **Recovery stage:** Once the disaster is over, the stage is set for returning to the original state. In some cases, such as weddings and funerals, it is difficult to

return to the original state, and a new state of New Normal must be formed. In this stage, the first step is to develop and rebuild the hardware and software infrastructure, followed by the reconstruction of the local community.

In designing such a series of processes, the question is how to minimize the damage to society as a whole, as illustrated in Fig. 3.1. It goes without saying that disaster prevention measures are more important than disaster response. Disaster prevention measures during normal times include, for example, raising levees and building evacuation facilities to prevent flooding, as well as issuing hazard maps to avoid damage, informing people about evacuation methods and routes, conducting drills, stockpiling necessary supplies, securing supply chains, and providing information about possible damage. In other words, the first step is to prevent damage from occurring, and if the damage is unavoidable, the second step should be to minimize the damage after the disaster occurs. What is also important here is the "stockpiling" of information, i.e., the creation of a database, so that the situation can be grasped immediately in the event of a disaster. This will be discussed later.

In the immediate aftermath of a disaster, it is not uncommon to be unable to obtain the information necessary for rescue and other responses, and thus be unable to provide appropriate assistance. However, in order to respond to emergencies to the greatest extent possible, it is necessary to clarify the roles and positions of the entities responsible for response, and to concentrate the functions of information and control towers on those entities. In other words, immediately after the occurrence of a disaster, the role of the basic local government and local businesses near the disaster area and the affected areas, and even before that, the role of community organizations such as neighborhood associations is important. It is there that information and resources must be gathered, and available resources must be effectively utilized to save lives and prevent the situation from worsening. At the same time, information on the disaster situation needs to be gathered and communicated to the national and regional organization task forces. In doing so, it is essential to systematize and compress the information. When information is sent in large volumes, it is often difficult for recipients to fully process the information and make incorrect decisions. In order to avoid this, it is effective to define the format of the information in advance and to send and process the information in a standardized way. Higher-level organizations that receive such information will provide assistance to the affected areas according to their priorities. Of course, the situation is uncertain, and too rigid and formulaic a process could lead to a mismatch between needs and resources. While it is necessary to ensure a certain level of redundancy, at present it is up to the local government to decide how to respond.

In any case, in order to minimize the gap between the local command center and the remote command center, it is necessary to share accurate and appropriate information as quickly as possible. To achieve this, it is necessary to first secure energy, as in Finland, and then develop the basic social infrastructure to ensure the stable operation of the information network. Based on this information, the national government and wide-area organizations will dispatch and transport relief units and supplies to restore the social infrastructure in the affected areas and maintain the lives of the victims. At

this stage, it is important to accurately and efficiently secure the supply of lifelines such as kilns and water supplies and other community infrastructure, as well as housing and other supplies necessary for the daily lives of residents. The so-called "traceability," a method of managing the supply chain of medical supplies, is expected to function.

Once the situation in the disaster-stricken areas has stabilized, full-scale reconstruction has begun, and the hardware has recovered, it is time to move on to community building. The time required to recover from a disaster and build a community that is as tough or tougher than before, as well as the human resources to carry out this task, will depend on the type and extent of the disaster. The time needed to recover from a disaster and build a community as tough as or tougher than before depends on the type and severity of the disaster. This way, the most appropriate actors can tackle the situation as needed based on the most up-to-date information, increasing the capacity for resilience in terms of both minimizing recovery time and achieving efficient use of resources.

In practice, however, despite the emphasis on the importance of role sharing based on information sharing, there are not a few conflicts due to differences in positions among relief officials from the national government, prefectures, and municipalities. This is due to the awareness of the mission and authority of their own organizations and the vertical division of administrative organizations. In order to reduce the distance between such differences and strengthen inter-organizational cooperation, it is effective to share information on the situations faced by other organizations and their evaluation criteria. With regard to the latter evaluation criteria, it is important to foster a common sense of values and trust by experiencing different positions through personnel exchanges during peacetime.

As mentioned earlier, in the immediate aftermath of a disaster, there is little information available from the hardest-hit areas. The key question is how can we understand the situation in areas where information that should have been available is not available? In order to make accurate guesses and assessments, it is necessary to accumulate information on the community and its residents during normal times, and it is important to establish a system to constantly update and share the latest information.

3.5 Utilization of Information in Disaster Response

We discuss the general concept of information systems in disaster response. Two specific cases are presented below.

3.5.1 Management and Recovery of Critical Infrastructure

Modern large cities are supported by extremely diverse and complex infrastructures. These include energy networks such as electricity and gas, lifelines such as water and sewage, communication networks such as fiber optics and cell phone networks, logistics that support urban consumption and mourning, and transportation such as roads and railroads that support the movement of people. If these critical infrastructures are damaged during a disaster, urban functions will be degraded. Damage to hard infrastructures caused by earthquakes and floods, as well as restrictions on the movement of people and suspension of infrastructure operations due to pandemics, will also degrade urban functions. Therefore, it goes without saying that in order to recover quickly and minimize damage in the event of a disaster, it is first necessary to take measures to prevent the occurrence of a disaster. To prepare for floods, various measures can be considered and many have already been taken, such as strengthening levees, building dams, stockpiling oil for power generation to secure energy, and securing stocks of medical supplies.

However, the structure of today's cities, especially those of Tokyo, Osaka, and Nagoya, is extremely complex and large in scale. Of course, the providers of services such as electricity, gas, and water must be aware of the vulnerability of their networks in the event of a disaster, and must be prepared in normal times so that even if their networks are damaged by a disaster, they can be quickly restored based on a recovery plan.

However, the structure and relationships among the various functions of an actual city are much more complex. It is a complex network in itself, and there are complex dependencies among these networks. For example, when the water supply network is damaged by a disaster, the first thing that the people in charge of water supply must do is to minimize the area of water cut off and the time required for restoration, in other words, to restore the water supply as soon as possible. To do this, we must hasten to repair the broken water pipes and secure the supply by changing the flow path. In doing so, they may have to rely on energy networks when it comes to using pumps. Therefore, in order to minimize damage to urban functions as a whole, it is necessary to take these dependencies into account in damage assumptions and recovery measures. This means grasping urban functions as a three-dimensional system that captures the interdependencies of various functions and flat networks within the city.

It is very useful to create a model of the critical infrastructure of such a city, identify vulnerable points through simulation, measure the impact of damage to these points, and find ways to prevent or minimize the damage. For example, if a disaster disrupts the power supply at a certain point, the power supply at that point could be compromised. For example, if a disaster disrupts the power supply at one point, how will other lifelines be affected? By knowing what methods are effective for restoration, we can predict the damage and find ways to minimize or avoid it.

When a disaster occurs, it is conceivable to build a system that shows the damage status and expected expansion in real time and indicates measures to prevent expansion and points where measures should be taken quickly and intensively. Figure 3.4 shows an image of a study conducted by Professor Furuta's team at the Resilience Engineering Research Center, Graduate School of Engineering, the University of Tokyo, based on this idea to model the dependencies of networks belonging to the critical infrastructure of the Tokyo metropolitan area. For each transportation and logistics, water supply, electric power, and information and communication, the team attempted to identify the actual networks and their interdependencies and analyzed them as described above. It shows the networks of water supply, electric power, and information and communication systems.

Hazard maps, which have been developed in recent years, can be used to guide evacuation, but they can also be used to predict damage to these critical infrastructures and how quickly they can be restored. Here, only electricity is shown as an energy system, but there are also gas and oil supply systems. Gas is supplied through a network of pipelines, and oil is transported on roads by tank lorries. In this way, supply depends on the road network. Energy is the most important factor in disaster preparedness, but in the event of a disaster, electricity and gas supplied by the power grid and pipeline networks will not be easy to restore if they are cut off in many places, and it will take time. On the other hand, oil systems transported by tank lorries are considered to be relatively easier to restore than roads, depending on the damage to the roads, and the network has by far the largest number of routes.

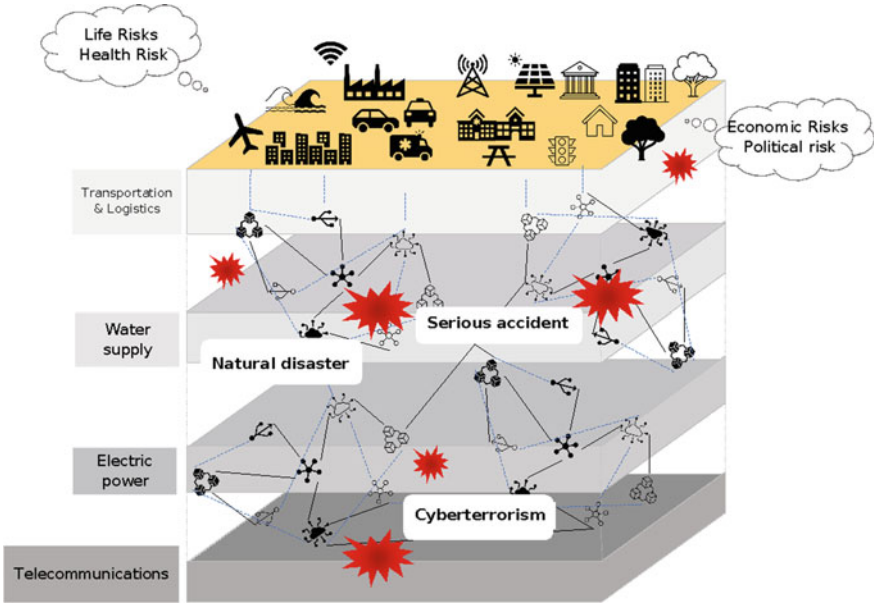

Fig. 3.4 Infrastructure vulnerabilities

Therefore, in the event of a disaster, prioritizing the securing of petroleum-based energy first to meet immediate needs, and then working on the restoration of other supply networks, would be the most efficient use of resources and would speed up the recovery process. If this is actually the case in many cases, the most effective way to deal with the situation in advance would be to promote the use of private oil power generation in various regions, and to relax as much as possible the current regulations on the transportation of hazardous materials such as petroleum products, which are strictly regulated for safety reasons, in preparation for emergencies, and to use the above It would be to take legislative measures to enable the necessary supply based on the simulation. Legislative measures should be taken.

Ideally, a system that can generate and provide necessary and accurate information in real time for response measures in the event of a disaster would be desirable, but in reality, it would be too complex and costly to build such a system to be useful in the event of an actual disaster. In reality, however, it would be too complex and costly to build such a system that would be useful in the event of an actual disaster, but it would certainly be effective in improving resilience. In order to get closer to the ideal system, we first need to collect and accumulate basic data, and then develop the information infrastructure so that it can be utilized. A complex and highly developed metropolis can be severely damaged by disasters. The development of such a system, which is effective in preventing disasters, minimizing damage when they occur, and speeding up recovery, should be promoted as soon as possible.

3.5.2 Post-Disaster Information Utilization

The second case of post-disaster information utilization is the use of personal IDs (My Number) to efficiently identify the needs of disaster victims and match them with the supply of necessary goods and services. The key is to match the information on needs with information on supplies, and to do so, it is necessary to quickly and accurately ascertain information on the attributes of the disaster victims, their health conditions, and the medications they are taking. At the same time, inventory information on the supply side is also essential.

It was reported that during the COVID-19 pandemic in Taiwan, the government used national IDs to check the inventory of masks at pharmacies and other facilities, as well as the number of masks held by each citizen, and established a system to ensure that those who needed them could obtain them in a short time. This is a successful example of information matching between supply and demand. This method has prevented masks from becoming unavailable due to hoarding or unreasonable price increases. In order to conduct such accurate and efficient matching, the use of personal information of the victims is a prerequisite. Of course, protecting personal information is also a matter of privacy. However, from the perspective of saving lives and maintaining livelihoods, it is necessary to evaluate the scope of protection and the possibility of its use.

A typical example of the need for such information collation is the response to disaster victims in evacuation centers after a disaster occurs. In evacuation centers, a large number of people of different ages, genders, health conditions, and lifestyles live together in an open space. In order to manage the health and maintain the lifestyle of these disaster victims, it is desirable to understand the various needs of each individual and respond to them in detail. Needless to say, it is desirable to utilize national IDs, or Japanese personal identification numbers, as is done in other developed countries.

Immediately after a disaster strikes, the first thing to be done in the disaster area is to confirm the safety of the affected people. Currently, the safety of the entire local population is mainly confirmed by the government, which makes a list of those who have evacuated to shelters or whose whereabouts have been confirmed in the community. In other words, at the entrance of the evacuation center, they check the 4' information of visitors, such as name, gender, date of birth, and address. However, this method is time-consuming and, of course, there is a possibility of omissions and errors. In addition, if family members are registered in different shelters, it becomes difficult to verify the information. In addition, when other medical personnel rushes to assist the evacuees, they are supposed to make their own lists and work based on them.

On the other hand, if Japan's My Number ID is utilized, such identification and subsequent actions can be greatly streamlined. Once a disaster victim is identified, his or her information is registered in the My Number system, and this information can be shared by family members and other concerned parties to facilitate safety confirmation. Such safety confirmation services are provided by cell phone companies, etc. By linking these services with the public registration system based on the My Number system, the situation of the disaster victims can be shared with relief and support agencies, and necessary services and supplies can be provided even without a request from the victims or their neighbors. This will enable us to provide the necessary services and supplies without any request from the victims or their neighbors. This allows us to provide necessary services and supplies even when there is no request from the victims or their neighbors.

For example, information on the status and number of injured disaster victims is very important in establishing a medical support system. As shown in Fig. 3.2, immediately after a disaster strikes, the medical care delivery system is under pressure. Under such circumstances, it goes without saying that information to determine the allocation and provision of available resources is very important. Furthermore, if GPS location information from cell phones can be used to rescue disaster victims, it will be possible to know the whereabouts of the victims without having to inform them or the people around them, thus enabling quick and accurate rescue. This will certainly contribute to the effective use of human and material resources for rescue in the disaster area.

Once a certain amount of time has passed since the occurrence of a disaster and safety can be ensured in evacuation centers, the next issue is to maintain the lives of the victims, as mentioned above. Compared to normal times, the living environment has worsened, and both physical and mental stress has increased. In such an environment, for example, in order to provide accurate care to the elderly with underlying diseases,

a system that can share the medical record information of the elderly with the medical personnel who perform medical treatment in the evacuation centers is effective. The same is true for infants. If allergy information is available in advance when providing meals, adjusted meals can be provided to disaster victims who need them. This is also true for the supply side. For example, in order to quickly and accurately provide supplies such as medicines, which are essential for survival and health maintenance, to disaster victims who need them, it is desirable to establish a system that allows constant confirmation of information on the production, distribution, and inventory of medicines and other supplies, a so-called traceability system, and to manage the supply process based on this system.

3.6 Way Forward

In particular, a disaster countermeasure system that utilizes the My Number will also make it possible to efficiently issue disaster victim certificates by linking them with geographic information. In addition, by linking My Number to bank accounts, disaster victims who have lost their bankbooks or bank cards can withdraw their deposits. The greatest benefit that digital technology has brought to modern society is the ability to provide customized services based on such detailed information of each citizen. As mentioned earlier, it is necessary to take full advantage of these technologies in order to respond quickly to situations such as disasters, where needs that do not exist in normal times rapidly increase and supply capacity decreases.

In the aftermath of the Great East Japan Earthquake, many evacuees left their places of residence without transferring their resident registration, resulting in delays and omissions of various benefits and other administrative services for evacuees, as well as huge delay costs for the procedures. Such a situation could have been greatly reduced if the whereabouts of the individual could have been easily confirmed using his/her personal number. It also goes without saying that this information can be used not only for the relief of individual victims, but also to narrow down and search for priority service targets by linking with other data and filtering by conditions. However, in order to utilize such a system, several problems need to be cleared in the current situation.

Firstly, the key to information coordination, which is the premise of such a system, is IDs such as my number. However, in order for this system to actually function in an emergency, it is necessary to accumulate information in a database on a daily basis during normal times. It is not practical to enter information only after a disaster has occurred.

Second, in order to use the My Number system to provide assistance efficiently and quickly, it is first necessary to verify the identity of the individual. This can be done if the individual has his/her own My Number card, but if not, the individual must either declare his/her own number or have someone else verify it for him/her. In Japan, few people will be able to remember their own 12-digit number, issued in encrypted form for various reasons. In many other countries, the date of birth and

gender are included in the number for ease of remembering, but this is not the case in Japan. The use of my number should be expanded so that people can immediately remember their number. In addition, biometrics and other methods should be used to facilitate identification.

Thirdly, there is the public's awareness of personal information protection, which is unique to Japan. Because of their historical background, the Japanese people are hypersensitive to the issue of personal information protection, and even though the My Number system is a convenient mechanism for modern society, its advantages are not being utilized. As discussed in this paper, this system will only be effective if it is used to efficiently rescue as many people as possible in times of disaster and other emergencies.

During normal times, it is important to protect personal information by limiting the linkage of information and managing information in a dispersed manner, but in order to utilize the system during emergencies, it is necessary to accumulate data on a daily basis and make it possible to link data as needed. It is important to emphasize here that an opt-in system based on consent will not be useful in times of disaster. It is necessary to review and improve the My Number system and the personal information protection system in anticipation of such a situation.

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Chapter 4
Emerging Issues and Japan's Milestones in Science and Technology for Disaster Risk Reduction

Sakiko Kanbara

Abstract The realization of wellbeing for each individual requires a style of innovation, and the early completion of Society 5.0 requires a change of gears, the development of new technologies, and the combination of existing technologies and social systems. Continuation of diverse lifestyles of individuals through the utilization of diverse personal data is what leads to DRR. In the first half of this chapter, the points that need to be taken into account in information sharing and communication were extracted and described based on the experiences and observations of disasters that occurred in Japan in the Society 4.0 era. In the latter half of the chapter, it was emphasized that the first step toward such "transformation" of society as a whole begins with "observation" of the actual situation. It was shown that it is important for the sustainable resilience of a region to break down the issues and resources in the region into small pieces, and to care them in the local community.

Keywords Human security · Wellbeing · Information communication technology · Care

4.1 Introduction

Natural disasters directly impact those affected, resulting in physical and psychological damage. In the immediate post-disaster recovery phase, disaster relief efforts undertaken by health care workers often require intervention. One of the most urgent tasks, as crucial as rescuing and treating the injured, is to provide supplies to the victims in the affected areas. On the other hand, victims frequently endure being deprived of food, water, and shelter until relief arrives. Therefore, it is essential to recognize the need to improve access to primary health care for victims of natural disasters. As health is defined as "a state of complete physical, mental and social wellbeing (WHO 1948)", it is necessary to establish a systematic protocol for disaster relief workers to ensure that individuals have access to primary health care during a

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time of disaster. Ensuring clean water, food, and sanitation are available in disaster areas is the most prominent and vital step in improving health security. It is also essential to know how to protect the elderly, women, and children and prevent the affected population from falling into vulnerable situations such as social poverty and underdevelopment.

Moreover, demographic changes and crises create multiple imbalances in sharing burdens and demands, both in the short and long term. Areas that were neglected and under-reported included the risk management of these conditions in the community and the impact upon delayed events and health problems (Bradshaw 2004). There is a need to promote universal access to health services for equitable health, the establishment of health care systems, human-centered health services, human resource development, and global health worldwide. The people most affected by the lack of universal access to health are those living in the most vulnerable situations (Cannon et al. 2003).

Various efforts have been made worldwide to develop technologies for disaster response. At the same time, advanced medical care and emergency services need to be concentrated in hospital facilities if we do not reduce prevention and risk at home and in the community. The burden on medical care and the spread of disease will become increasingly severe, and disasters may have the worst possible consequences (Rentschler et al. 2021).

This chapter highlights the importance of linking science policy practices to sustainable development by presenting the experiences of technology diffusion within Japan and the critical lessons learned from various community-based activities. However, individual baseline and research data are being produced in increasing quantities to serve as the indicators for the new global agenda by 2030. There is a need to construct cross-sectional databases and risk reduction models across disciplines such as meteorology, geology, civil engineering, social science, health, etc. The realization of wellbeing for each individual requires a style of innovation; early completion of Society 5.0 requires a change of gears and the development of new technologies and the combination of existing technologies and social systems. It also explored why "co-creation with sustainable community" through the case study.

4.2 Lesson Learned from Disaster Responce and Information Management by DRR3.0 × Society 4.0 in Japan

Information sharing has been done by having representatives from the relevant departments of the disaster response headquarters gather in one place. The concern was how, when, and where to share the collected and organized information with the most severely affected "local task force" or the prefectural task force-missing this goal led to information confusion and delays in decision-making. It is organized into items by departmental resources in charge of human casualties, property damage,

and response. However, the issue was how to share the information collected and managed by each site individually.

4.2.1 Systematization of Sharing Data

For the individual lifelong and disaster risk reduction in the community, time is the only universal axis that runs through the disaster process. The use of maps in the immediate aftermath of a disaster can significantly improve information sharing and consensus-building among organizations, facilitating rescue and recovery efforts (National Research Council, & Mapping Science Committee 2007).

The imbalance between supply and demand of health care, local disaster management as self-help by citizens mutual assistance to save lives should be organized to support public assistance that enables decision-making for a rapid response and the appropriate recovery. It would be easier to track, manage, and update the information reported from each site that should be prepared continuously.

In this regard, it is essential that: (1) Both parties should have the knowledge and skills to share information immediately in an emergency, (2) Extract meaningful information from a wide variety of information, (3) Identify specific ways to predict and share physical, technical, and linguistic barriers, and (4) Trust between the sender and receiver, especially that the receiver will take the message seriously. It is desirable to organize the information in chronological order for each source of information, such as local governments, medical teams, public health nurses, external ancestor organizations, and citizens. Also, it is crucial to promptly document the information as the "latest information" after sharing it regularly with those who are not present at the sharing.

Structuring the latest information materials and updating them with a precise date and time while preserving older information makes it possible to visualize the progress of the response. It is also easy for other media to update them. In addition, secondary use is complicated due to data format issues if the information is only published on a website, and multiple pieces of information cannot be combined for practical use. Each department's data, which can avoid duplication of work, has its characteristics. It is required to decide what data can be shared between administrations, what cannot be shared by NGOs, and rules on sharing data on individuals and the granularity of information. In advance, it is necessary to understand which data can be shared and which data need to be protected within the organization.

4.2.2 Collection, Design and Data Uncertainty

The first piece of information that should be collected is the damage caused by the disaster. Especially the damage to public infrastructures such as electricity, water, gas, communications, transportation, fires, industrial accidents, evacuation of people, and

confusion (Cabinet office 2020). Information can be obtained more quickly through social networking services such as Twitter. If the information is the same from both sources, it is likely to be accurate; if it is only on social networking sites and cannot be confirmed directly, it may have been resolved, moved, or spread (Sakurai and Murayama 2019). What is most worrisome is the blank area where the damage is presumed, but no information is available. The areas where no phone calls are being made or connected may be terrible. Rather than waiting for information reports from these areas, we need to immediately go there and confirm the information as a team, including lifesaving and rescue teams. Damage does not depend on the name of the place or the geographical boundaries of the municipality. In other words, even if an area is named in the information as damaged, some places are affected while others are not. A common understanding of location information on a map will lead to accurate information sharing. It is necessary to consider a system in which a regional staff member in charge, who is familiar with the local geography, can grasp the district's situation and make efforts to understand it.

Various supporters, volunteers in the field, and employees who seem to have nothing to do with health and medical care, may also have important information. In addition, it also requires an attitude that collaboration with all other professions is essential. There is also a need to connect with the broader community, for example, by using social networking services (SNS) and other forms of communication that residents use daily. Alternatively, by using web forms to confirm each other's safety quickly, by using grassroots activities to try to solve problems, or by listening to the voices of those who cannot speak up. On the other hand, gathering information from inside communities with information barriers, such as physically isolated places, technologically disrupted communication, and linguistically inaudible or unreadable, varies greatly depending on the information provider and listener, making it difficult to share. The non-verbal insights found in communication between vulnerable people and last-mile connections are also expected. At the same time, it is vital to be aware of gender, position, crisis, and vulnerability, respect it and subsequently protect it before being exposed to danger.

4.2.3 Processing of Information into Usable Information

There have been limitations in quickly analyzing data that can define the number of disaster victims, visualize the original demand, and determine the correct balance of supply and demand for public health care. The balance needs to distinguish between the chaotic phenomenon of forced migration away from the actual residence and mutual aid outside the familiar government and support system. Even with any data and information being received. It is necessary to analyze the situation with a biased opinion of the received information due to communication channels not being first-hand, i.e., essential information linkages cannot be established. The main common points regarding issues related to information management in healthcare

during disasters: (1) Pre-disaster information is useless due to the movement of residence, (2) IT infrastructure is uncertain, (3) Accessibility to information and data cannot be confirmed, (4) Inability to visualize welfare and residents' insights, (5) Simultaneous release of information with time differences, (6) Discrimination in information duplication, (7) Ensuring reliability and validity, (8) Setting cross-cut points for reporting information, (9) Vulnerable situations and people are overlooked, and (10) Information is not reported as improved. It is essential to recognize these factors and issue information that can be used to determine responses, instructions, and subsequent analysis (Kanbara and Shaw 2022).

4.2.4 Importance of Monitoring Over Time

In a chaotic situation such as an immediate crisis, initial assessment information can determine whether any omissions in the response, including crisis avoidance, will result in people's loss of life or death and the prevention of secondary disasters. It is necessary to manage the situation and prevent omissions in the response (Bayntun et al. 2012). Specifically, the response level needed should be determined, such as first aid and transport to the hospital being provided for the seriously injured, the slightly injured, the unidentified, and those requiring medical care, and how and by whom the search is being conducted for the unknown. If detailed information can be collected to identify high-risk and vulnerable groups, equitable support and evaluation will be provided. Even within a single municipality, population density and disaster risks are diverse, and organizations involved in disaster prevention are changing. It is difficult for the government and supporters to conduct a simultaneous survey that identifies risks, needs for consideration, and vulnerabilities throughout the community. As well as having evacuation centers as one group, agreements should be made with local facilities, businesses, and schools to provide information on specific areas and incorporate information by citizens into community disaster prevention plans and health and welfare projects (Fig. 4.1).

4.2.5 Systematic Implementation of Information Collection and Organization

Because both the post-disaster situation and the information collected from people are fluid, it is necessary to extract information correctly based on time, subjectivity, and inter-organizational collaboration changes. It is important to note who should itemize the output when collecting and organizing information. At the very least, operational and human resources and things should be organized, feasibility should be examined, and the manuals should be updated to enable co-work to manage tasks and shift schedules for personnel roles. It is necessary to improve processing methods to enhance

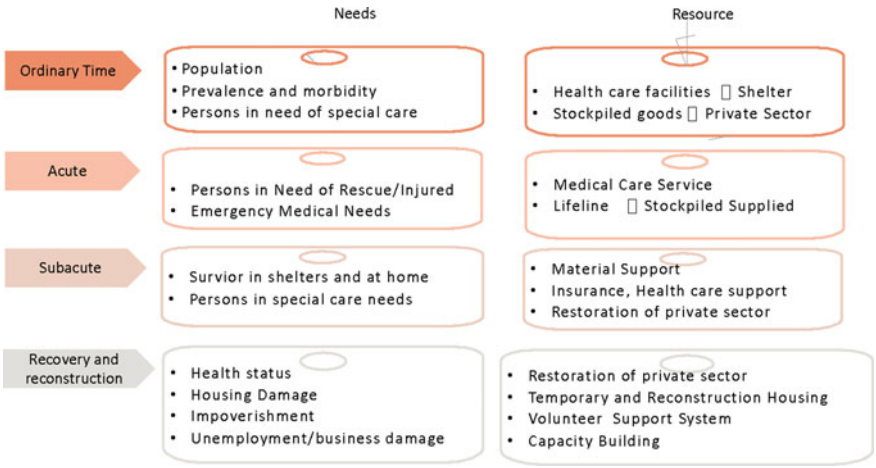

Fig. 4.1 Examples of resource and information needs for each disaster phase

information collection and dissemination functions and consider the unification of information reporting and processing methods and reporting formats.

In addition to the necessary personnel, it is essential to determine how many information devices and equipment will be needed and check their operation at least once. For example, in light of the congestion and limitations of cell phones and mobile e-mail, it is necessary to introduce satellite phones, IP phones, Wi-Fi, etc., to multiplex the system so that safety confirmation can be done without relying on a single channel. On the other hand, rapid communication via the Internet might make it easy to overlook important information. Information should be collected and disseminated based on analysis, and decision-making needs can be centrally managed and scrutinized in such a large room foremost. Also, it had better consider the situation and unify the collection tools to be used as soon as possible.

4.2.6 From Statistical Thinking to the Utilization of Non-Aggregated Data

Some overall average values are too high or stick out from the normal distribution, unlike regular times. Unexpected results can be obtained from them, and effects that cannot be explained need to be qualitatively delved into new findings. On the other hand, it is also significant to be aware that data may be entirely unchanged from regular times, contrary to expectations. There is a possibility that the voices of those who are enduring and vulnerable are not included. It is also our responsibility to confirm the facts while respecting non-aggregated data as the most solid scientific truth, rather than discarding informal and qualitative information and voices that are difficult to visualize, and that come from the voiceless. In the current situation,

where ICT and IoT are becoming the norm that can break through the barriers, dramatic progress is expected for a response based on almost real-time analysis. For this reason, the information analysis and operation planning section needs to be strengthened separately from the team on information collection and communication (Erman et al. 2021).

As for the analysis itself, it is imperative to take a bird's eye view of the disaster site using descriptive epidemiological methods (Rothman 2012). Therefore, standardized metadata for time, location, and attributes, which are the basis of epidemiology, should be added to the various information, which will lead to a variety of subsequent analyses. By displaying the data spatially and looking at differences from ordinary times and from region to region, it is possible to improve support fairness in the future. By looking at fixed-point data from various groups over time, it is possible to confirm differences in change.

For advanced analysis, universities and companies would become volunteers to collect the data if they reach out to people who can handle GIS and IT across disciplines. It is also vital how to collaborate with such external supporters.

4.2.7 Message Distribution

In the acute phase, it is necessary to share the information quickly. Consider promptness in the acute phase and timing according to needs in the subacute phase and beyond. The latest information can be disseminated to the outside world by sharing it prior to the countermeasure meeting or by adhering to deadlines for newspapers and media while considering confidentiality (Cabinet office 2010). This continuation leads to transparency and trust, and both parties can actively participate in obtaining information. Dissemination from higher-ups and professionals in the task force will lead to credibility. At the very least, the loud voices of vulnerable people and women should not be allowed to disappear from the record. Sensitive information about minorities should be considered for distribution, several copies, and handling.

4.2.8 Consensus Building: Decision-Making, Accountability, and Collaboration

It is necessary to have a leader who can make decisions based on various opinions from a bird's eye view. It is not a matter of having a good sense but continuous training in tactics (Dyess and Sherman 2009). The participation of diverse people and transparent communication, the human-centered approach, the involvement of the people, the coordination and integration of multiple fields, and the use of appropriate technology is highly appreciated to achieve the target.

In addition, it is necessary to establish a system of cooperation that links various experts, specialized organizations, support groups and support companies that can provide advice and collaboration on multiple issues related to health, medical, and welfare and peripheral areas to respond quickly. Sharing information on good practices and ideas from different perspectives will lead to more efficient resources and time. The collaboration will also prevent the burden of repeated investigations by the same people. It is necessary to conduct After Action Reviews (WHO 2019) and continuous monitoring to understand vulnerabilities, response capabilities, and lack of resources. It is also imperative to identify predictable and avoidable risks and create a cycle for improvement, rather than just concluding with an internal evaluation report.

4.3 Observation to Orient, Decide, and Act: Demand Based Innovation on Emergency

The risk environment is rapidly changing, with extreme weather events, natural disasters, and unknown virus outbreaks on a global scale, while information technology is quickly advancing and social systems and people's literacy are changing rapidly. Such a global situation, Boyd's OODA loop (Von Beakley and Patricelli 2008) that was used in the military, is now used in politics, education, startups, and companies as a business model. In the context of the lessons learned as described in the previous section, approaches to existing knowledge management, technical issues related to access to relevant multi-disciplinary information and knowledge, and decision-making processes based on past disaster management systems have become more complex. As a result, the management of large-scale disasters is often inefficient and may be very costly.For further disaster risk reduction, it is necessary to understandinnovation processes that occur in daily operations and to effectively and take advantage of efficiently incorporate science and technology. The following unpredictable and dynamically changing health crises demonstrate the beginning of science that innovative solutions can be derived and resolved by employing decision-making based on the OODA (Observe, Directions, Decide, Act) loop, which begins with observation.

The Industrial Revolution brought a rapid influx of workers to cities at the beginning of public health. However, no environment and system could ensure all health and well-being. The standard of living for low-wage workers was miserable and threatened human security. The Crimean War broke out in 1854; many people died, not from the fighting itself but from infections, epidemics, and starvation. Nightingale observed simple cleanliness and a sense of smell, making it essential to look good and not stink by working on basic hygiene and diet to care for wounded soldiers. She explained using infographics to reveal the unsanitary conditions (spread of infectious diseases) in hospitals. The mortality rate of wounded soldiers dropped (Fee and Garofalo 2010; Gill and Gill 2005; Cohen 1984).

In 1854, John Snow, known as the father of epidemiology, discovered from his community observations that people who drank contaminated well water suffered, then established epidemiological methods to elucidate the source, route of infection, and biological factors (such as pathogens). Even though there were some unknowns, observing social factors and conditions, the epidemic of infectious diseases was contained. (Snow 1855). Before 30 years, Robert Koch discovered Vibrio cholera (Lippi and Gotuzzo 2014).

In Japan, in 1833, a warship on a training voyage to South America produced 169 cases of severe leg sickness out of 376 crew members, 25 of whom died. Navy doctor Kanehiro Takagi, noting the difference in diet, procured meat and vegetables from Honolulu harbor and fed them to his patients, all of whom recovered. Relying on British evidence-based medicine, he assumed that the lack of protein intake was the cause of the disease, tried a Western and wheat diet, and dramatically reduced the incidence from 23.1% in 1883 to less than 1% in two years after its introduction in 1884. Although the theory was wrong, the scientific evidence for epidemiology was obtained as a preventive measure against beriberi. His discovery of the cause of beriberi 15 years before the discovery of anti-beriberi vitamins by Aikman and others is highly regarded overseas (Sugiyama and Seita 2013).

Primary social analysis can be understood through on-site observation during emergencies. Everyone involved in clinical and public health practice recognizes this when living in a disaster and providing services to people with threatening human security. Today, people are increasingly taking advantage of vaccines, diagnostics, and effective treatment kits. However, health disparities exist in the context of social forces such as racism, pollution, poor housing, and poverty that shape pathways within individuals, families, and groups (Bailey et al. 2017).

In uncertainty, expectations are high for problem-solving based on social and human sciences thinking. Information related to disasters, life, and health should not be focused on only the occurrence of emergencies. It is essential to consider indicators and methods that allow for deep and continuous monitoring of disaster risks and district understanding and diagnosis to take measures in public health and health policies and projects during normal times. If a disaster strikes, the prognosis for all aspects of the community is uncertain, budgets may not be fixed, ethical considerations are localized, cross-sectoral, forcing us to respond to crises in a way that cannot be designed or pre-tested. 2018 It is then necessary to consider and prepare for collaboration across disciplines and fields, norms of behavior based on users' information literacy and roles, and ways to engage people while observing social trends. Native researchers, technologists, or practitioners may sustain the initiative as local citizens (Kanbara et al. 2020).

4.4 The Role of Local Institute: Co-Creation of Care Science for Disaster Risk Reduction

Once a disaster strikes, people's access to routine medical care will be complicated. Medical tightness will occur, leading to poor sanitation and health conditions in evacuation centers and the community. Nurses, the primary health care providers in the community, are often called upon to gather information amidst the chaos and coordinate with local hospitals, city halls, and public health departments to assist. The Science Council of Japan proposed "care science," a new system of knowledge in which multiple academic disciplines, citizens, and government agencies work together to address common social issues related to care. The goal is a mutually supportive society built by embedding care science and its results in people's lives (The Science Council of Japan 2020).The university's mission also includes contributing academically to the development of the local community. Local universities must co-create knowledge and skills in a sustained manner, both suddenly and in the face of recovery due to disasters. More than 270 nursing colleges and universities in Japan (JANPU 2022) are required both functions, and need to experiment, verify, and pioneer disaster risk reduction by the times, including the latest information sharing, so that they do not panic when a disaster strikes in their communities (Kita et al. 2012). As for local disaster reduction involving universities, they are the integration of education and research, the effective utilization of knowledge and its new development, and the upgrading of communities and their active involvement and participation in disaster risk reduction. This case study will introduce a people-centered approach to community disaster management through nursing at a public university in Kochi Prefecture and emphasize the importance of community engagement in university community disaster management.

Kochi Prefecture is affected by typhoons and heavy rains every year, a phenomenon frequently seen in developed countries due to climate change. Furthermore, there is a 70% probability that an earthquake of magnitude eight and a tsunami of 34 m high will occur within 30 years. With the super-aging society, the shortage of doctors in remote areas is becoming a problem in the region. The 1998 torrential rain and floods triggered the Kochi Disaster Nursing Support Network (damage: 6 people killed in the prefecture, 12 injured, 12,380 houses flooded above floor level, 9,885 homes flooded below floor level (Shikoku Disaster Information Archives 2022). At that time, with the implementation of the Decentralization Act, there was a growing tendency for local governments to deal with regional disasters, and the role of municipalities in times of disaster was becoming more extensive. It makes sense for municipalities to make decisions since they have the best understanding of the situation and needs of the affected areas. Still, municipalities are faced with issues of human and financial resources. The necessity for the prefectural government and municipalities to work together in response to disasters was understood. The Kochi Prefecture Disaster Nursing Support Network Study Group organization was adopted as a project proposed by Kochi Prefecture officials in 1999 (University of Kochi 1999). In the course of these activities, research acquired by the university

budget and team members has been conducted, information sharing meetings and events have been held, and agreements are signed to strengthen cooperation between the university and related institutions. In addition, the university has established the Global Leader Development Program under the MEXT's Leading Program for Doctoral Education, and doctoral graduate students have been participating in local projects to deepen their research and learning and contribute to disaster mitigation in the region.

For example, Kochi Prefecture Nurses Association, in collaboration with universities, has started to train its own "Community Disaster Support Nurses." That prepares to respond locally and rapidly to a large-scale disaster in the event of a predicted Nankai Trough earthquake after the Great East Japan Earthquake. The Japan Nurses Association has been dispatching disaster relief nurses to the disaster area as a nationwide effort that takes about three days to dispatch the nurses by request from the disaster area coordination.

In another case, with the strategic research funding by the President at first, they worked on "Mapping and Socialization of Care for DRR that Leaves No One Behind" in Kochi Prefecture. We devised a system that allows communities to share map information necessary for evacuation, living during the evacuation, and returning to daily life, especially for disabled people and women raising children.

It was challenging to adjourn the research activities and still sustain in the community. By positioning Kochi as a "research station" in the field, local industry, government, academia, and the private sector while utilizing their respective strengths, have continued to care for DRR. Fund and requests for co-creation came in from Kochi City and other local governments, which led to the development of Community Based Participatory Research (CBPR) to propose solutions that fit the actual situation of the local government or organization. The specifics of the research appear in several scenes in Chaps. 5, 6, 7 and 8 of this book.

Through repeated workshops and drills with residents, especially those in need of care, we explored the development of community-participatory research methods and social contributions as a prefectural university with industry-government-academia cooperation and collaboration. What gradually emerged from the research activities is that we should develop a sustainable communication ecology as a form of human security to not repeat the same problems in the local community. People require personal communication, personal data, and livelihoods to protect themselves in emergencies. Through the operation of IoT and communications, residents' lifelong health status and medical information can be visualized to meet their essential health and wellbeing. They continue explore self-care and local mutural care in community so thatindividuals can provide their PLRs to enable essential health management, which can be fine-tuned to consider their human rights need.

4.5 Way Forward: To Distributed Sheltering and Communication and Care

In the information society of the past (Society 4.0), information sharing in the community was inadequate. In the society to be realized in Society 5.0, "all people and things will be connected by the Internet of Things (IoT), and various knowledge and information will be shared, creating new values that have never been seen before.

Activities related to disaster response are diverse, ranging from small-scale activities by individuals to large budgets involving national and international organizations. However, we need to be aware that the results of these activities will provide information that will be useful for future disaster responses, and we need to disseminate this information. The results of these efforts will be helpful information for forthcoming disaster responses. Participatory change needs to occur from the forming stage, with vulnerable people contributing to regional and community development and private investment considerations.

The community-based approach involves looking closely at phenomena, such as concerns about living life and wellbeing. For a people-centered approach, it is essential to combine different research methods. In recent years, computer technology has advanced data analysis, complex models that contribute to disaster and social research approaches are being analyzed, and strategies are becoming more diverse.

When co-designing a single project, it is necessary to understand what objectives, when, and types of research can be applied. It is essential to consider the feasible data collection for each study, which research methods will be used for data collection and analysis, and whether the data analysis will focus on quantified or non-quantified data. Researchers will be expected to articulate the purpose of using qualitative data and quantitative data. It is essential to understand what types of research can be applied ethically. Data collection itself is often a significant constraint in the data processing flow. Reviewing data collection will allow for a more realistic logic and discussion. Then, identify the resources available for the analysis and visualization phase. The vast amount of data generated in various fields need to be utilized cross-sectionally to share knowledge and information throughout society. To this end, it is necessary to promote the disclosure and distribution of knowledge and information and promote cross-sectoral collaboration to care for people rather than harm them. On the upper stream of that, it is required to solve technical issues based on institutional problems and international trends in technological development.

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Chapter 5
Evidence-Based Policymaking of Smart City: The Case of Challenge in Maebashi City, Japan

Yuki Akiyama, Yoshiki Ogawa, and Osamu Yachida

Abstract Since around 2017, the Japanese government has been actively considering Evidence-Based Policymaking (EBPM) to make various statistics accurate and to plan and select effective policies with limited budgets and resources. Using big data in planning smart cities has realized its full potential and "smartening" urban governance achieved in specific contexts. For this purpose, "micro-geodata" is big data with location and time information and is expected to be utilized for spatiotemporally detailed planning and analysis, etc., which could not be achieved with existing various types of statistical data. This chapter provides some case studies on Micro Geodata that created added value to governance on disaster recovery and risk reduction in Japan, and one case study about "Slow City" by reducing the burdens of daily life through the realization of a "super city" using the latest digital technology. It would suggest that differentiated strategies should be employed for improving governance processes and handling related urban problems.

Keywords Evidence-Based Policymaking (EBPM) · Smart city · Slow city · Super city · Micro Geodata (MGD)

5.1 Introduction

5.1.1 What is "EBPM"?

Evidence-based policymaking (EBPM) is a term in the field of public policy studies that refers to the practice of basing policymaking on objective evidence such as statistics and data (Parkhurst 2016). EBPM is considered to be a concept that extends and

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applies the idea of "Evidence-Based Medicine (EBM)," which originated in the mid-nineteenth century and has flourished since the 1980s, not only to the medical field but also to the field of public policy studies (Sackett 1997). However, compared to the fact that EBM is scientifically rigorous and quantitative evidence (i.e., quantitative data) is easy to collect and analyze, some of the policy-relevant evidence in EBPM may not necessarily be quantitative information, or it may be difficult to collect such information. Therefore, even today, the methodology is still being debated internationally (Petticrew and Roberts 2003). It is said that the history of EBPM can be traced back to the fourteenth century. However, in recent years it has been popularized by the white paper "Modernising Government" by the Blair administration in the UK (Banks 2009). In the white paper, the British government noted that the "Government must produce policies that really deal with problems, that are forward-looking and shaped by evidence rather than a response to short-term pressures; that tackle causes not symptoms."

Although there are many methodologies in EBPM, they generally have the following common features:

1. Consider why the policy is likely to be effective and what the impact will be if the policy is successful.
2. Consider what will happen if the policy is not implemented.
3. Indicate the direct and indirect impacts and effects based on quantitative evidence that is expected to result from the implementation of the policy.
4. Consider not only quantitatively assessable factors that affect the policy but also highly uncertain factors that are difficult to quantify (qualitative factors) in order to consider the impact of the policy on the surrounding area where it will be implemented.
5. Form that can be reviewed and reproduced by a third party.

Through a cost–benefit analysis approach, the above features can be said to be for estimating the net benefits of a policy when it is implemented. However, as mentioned earlier, there are not a few variables that explain policy-related causality that are difficult to quantify. Therefore, EBPM is characterized by the fact that it focuses broadly on whether or not the benefits exceed the costs, rather than a method of quantitatively estimating and accumulating the benefits of the individual projects that comprise the policy. It is also characterized by the active use of data and statistics, especially to present quantifiable evidence (Banks 2009).

While the above is the international concept and current status of EBPM, we will now introduce the current status of EBPM in Japan. In recent years, EBPM has been defined in Japan as "efforts to effectively utilize limited resources and develop a more trustworthy public administration in the midst of a rapidly changing economic and social structure." It is also pointed out that in order to promote EBPM, it is important to develop and improve the statistics and data that are necessary to build the evidence for it (MIC 2018). Furthermore, as EBPM is promoted, statistics and data that reflect the needs of the entities that implement EBPM (national and local governments) are further required, and it is expected that the improvement of policies and the development and improvement of statistics will proceed simultaneously. Therefore,

it can be said that the development and utilization of statistics and data is an important national task in conjunction with the promotion of EBPM. Hence, in August 2017, the government held the first meeting of the EBPM Promotion Committee, and from April 2018, each ministry and agency have its own director-general for EBPM. In this way, the system for promoting EBPM by the Japanese government has been rapidly developed.

As described above, the concept of EBPM in Japan is generally in line with the international concept of EBPM. In addition, it can be said to be unique in that it clearly states that Japan will put particular emphasis on the development and improvement of statistics and data necessary for evidence building.

5.1.2 Challenges in Promoting EBPM in Japan

In Japan, the momentum for EBPM promotion is growing at the national level. On the other hand, at the level of each national ministry, agency, and local government, although they understand the significance of EBPM promotion to some extent, there is an overwhelming lack of ideas on how to tackle EBPM, such as what kind of statistics and data should be collected and what kind of analysis should be conducted. Moreover, there are not a few decision-makers in national and local governments who are skeptical of EBPM. It is said that this is due to the fact that the policymaking of the Japanese national and local governments has emphasized the success stories of past local cases and experiences (episodes) (MIC 2018). Post-World War II Japan certainly has experience in achieving unprecedented economic growth through government-led "policies" (Kato et al. 1994). However, it is inevitable that policies based on past practices and successes will be ineffective in achieving some of the policy goals that need to be achieved today. The above policies that are not necessarily based on evidence, but are formulated and implemented based on the "experience," "intuition," and "assumptions" of policymakers were often positive in terms of cost–benefit analysis for a while after the collapse of the bubble economy in the early 1990s. Incidentally, such a policymaking stance is commonly referred to as "KKO (Keiken (experience), Kan (intuition), and Omoikomi (assumptions))" in recent years in Japan. This is due in large part to population growth and the resulting rapid economic growth and expansion of domestic demand. However, today's Japan has entered a phase it has never experienced before: 30 years of low growth after the collapse of the bubble economy, a rapidly aging and declining population, and a decline in international competitiveness. Therefore, it has become difficult to formulate policies in which the benefits exceed the costs by relying on the KKO-based policymaking. For this reason, EBPM is an indispensable concept for the sustainable growth of Japanese society, which has entered a phase that has never been experienced before.

As described above, the importance of EBPM in Japan is increasing, but at the same time, there are numerous issues to be addressed in promoting EBPM in Japan. In particular, there is a lack of sufficient high-quality data and statistics that are useful

for promoting EBPM, or even if high-quality data exists for policymaking, it is not easily accessible to policymakers (Tsuda and Okazaki 2018). Another issue is the lack of human resources (data scientists) who can perform relatively advanced data processing and analysis in order to promote EBPM (Fujita 2021). The Nihon Keizai Shimbun, a Japanese newspaper, has also ridiculed Japan as a "developing country" in terms of policy evaluation for this lack of progress in promoting EBPM (Nihon Keizai Shimbun 2017).

Although there are many challenges in promoting EBPM in Japan, Japanese society is not just sitting on its hands. In recent years, a variety of statistics and data useful for promoting EBPM have become available. In addition, the use of such statistics and data to understand regional issues and to provide analysis results that contribute to EBPM is beginning. In addition, the "Super City Concept" in Japan is being developed as an environment for promoting EBPM in local governments.

Therefore, this chapter introduces "Micro Geodata (MGD)", which is spatiotemporally high-definition spatial information useful for promoting EBPM, examples of MGD applications, and The Super City Concept and the Slow City Concept in a Japanese Regional City: Maebashi City and discusses the future prospects for promoting EBPM in Japan based on the above contents.

5.2 Micro Geodata (MGD) to Support EBPM Promotion and Available MGD in Japan

Obtaining quantitative evidence is an important factor in promoting EBPM. In this case, MGD can be a very useful piece of information. The authors collectively refer to MGD as spatio-temporal high-definition and highly reliable spatial information that enables us to understand the distribution and movement of individual buildings, offices, people, and so on (Micro Geodata Forum 2021) (Fig. 5.1).

A variety of MGDs are available in Japan. For example, by using a digital residential map or a digital telephone directory, you can know the spatial distribution of individual houses, stores, and business facilities all over Japan. In addition, the vast amount of information on people's movements collected through individual cell phone communication records and GPS locations: cell phone big data, and cell phone statistics processed from such information can be said to be the most representative spatial big data in MGD. Moreover, as will be introduced in this chapter, local governments have a variety of MGD (municipal MGD), and the integration and utilization of these MGD can also produce results that are useful for promoting EBPM. In particular, although municipal MGD has high restrictions on its use, such as the need for confidentiality of personal information and barriers to its use for other purposes, it is pinpoint data that is updated frequently and is highly reliable, making it extremely valuable for local operations and management.

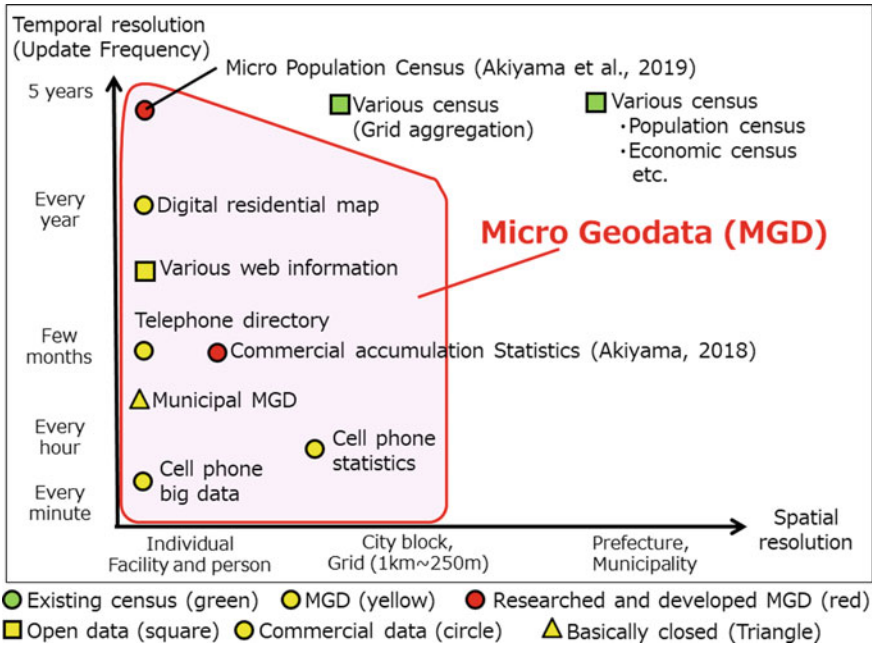

Fig. 5.1 Examples of available MGD in Japan

5.3 Application Example of MGD: High-Definition Damage Simulation of a Large-Scale Disaster

In this section, as an example of advanced research using various types of MGD, we will introduce a study on the use of MGD for high-definition damage estimation caused by natural disasters, especially large-scale earthquake disasters (Ogawa et al. 2019a, b, 2021). Japan is a country with many natural disasters on a global scale. According to Gu (2019), the risk of mortality and economic vulnerabilities especially due to typhoons, earthquakes, and floods is very high in many cities of Japan. In particular, the damage caused by a large-scale earthquake can be enormous in terms of human and economic losses, and the catastrophic damage caused by the Great East Japan Earthquake is still fresh in our memories. Therefore, in Japan, the national and local governments are preparing for possible future earthquakes and tsunamis in order to improve disaster prevention measures and community awareness. (Cabinet office Japan 2020; Tokyo Metropolitan Government 2016). In addition, with the development of simulation technology using high-performance computing, both the estimation and prediction of property damage and casualties from earthquakes, tsunamis, and associated fires (called complex disasters) have been improved by using various MGD related to urban environments (Hori et al. 2017; Ogawa et al. 2019a, b, 2021). Fortunately, in Japan, as mentioned above, there are many kinds of MGD available for understanding the current status of cities. However, many

previous studies are based on only a very small number of disaster scenarios or do not fully utilize MGD due to problems of access to data and technical issues. Damage estimations based on such a small number of scenarios may lead to shocks caused by unexpected damage. The accident at the Fukushima Daiichi Nuclear Power Plant during the Great East Japan Earthquake is a typical example of "shock caused by unexpected damage."

In general, the vulnerability of a city is determined by a number of factors related to the urban environment, such as the attributes of its inhabitants and urban infrastructure. When information on the urban environment is used as an explanatory variable, it is very important to clarify the factors that determine urban damage (objective variables), i.e., the potential structural relationships between explanatory and objective variables. In order to clarify this potential structural relationship, we propose a sparse modeling (SpM) method that identifies a set of variables that characterize the damage state from data on external disaster forces (estimated earthquake seismic motion, tsunami height, etc.) and the urban environment. This method will allow us to identify urban environmental elements that contribute to the improvement of infrastructure and evacuation planning, and thus provide evidence for more efficient and robust urban planning.

Figure 5.2 shows the flow of data, damage estimation, and evaluation of the urban environment approach proposed in this study. In the proposed approach, the damage estimation is divided into two steps. First, we estimated the damage of about 30,000 scenarios integrating seismic intensity (SI), fire, and tsunami using the building MGD (Akiyama and Ogawa 2019), which estimated the structure and construction age of about 60 million buildings throughout Japan, and the MGD, which is big data of cell phone movement trajectory, as input hazards for tsunami run-up, and simulated the results of seismic motion on a supercomputer. Since the scenarios include the conditions of various events, it became possible to assume more scenarios than ever before and to clarify in detail the spatial distribution of damage and the maximum amount of damage for each region. Next, we used SpM to analyze the maximum damage and urban system variables for each city and extracted the most important urban environmental variables of earthquake damage. Finally, by visualizing the results using radar charts, we were able to identify the urban environmental variables that characterize the damage in the region. The results of this analysis are very useful in promoting EBPM in the field of urban disaster prevention, as they provide evidence of which specific urban functions need to be improved and updated in order for local governments to promote disaster-resistant urban development. In the future, we are considering extending this study not only to damage estimation but also to resilience assessment in the recovery phase to provide evidence that enables EBPM not only for pre-disaster but also for post-disaster response.

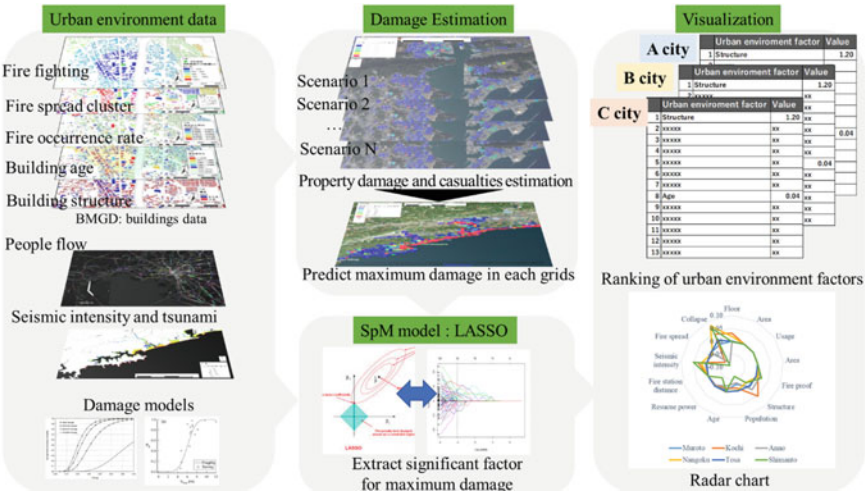

Fig. 5.2 Overview of the proposed damage estimation approach. BMGD: Building micro geodata; LASSO: least absolute shrinkage and selection operator

5.4 The Super City Concept and Its Challenges in Maebashi City

5.4.1 The Super City Concept of Japan

The "Super City Concept" in Japan refers to the super city-type national strategic special zone, in other words, the national strategic special zone that will realize the future society of 2030, 10 years in the future (Cabinet Office Japan 2021). The goal of this concept is to create a municipality that realizes Society 5.0 (Onday 2019) through various regulatory reforms and digital transformation (DX) of various operations using the latest digital technologies. Even before and during the world pandemic of COVID-19, there were countries and cities that were able to respond to Industrial 4.0, or Society 5.0 in Japan (Safiullin et al. 2019). Examples include Estonia and Singapore at the national level (Goede 2019), Barcelona in Spain (Bibri and Krogstie 2020), Amsterdam in the Netherlands (Capra 2019), and Hangzhou in China (Caprotti and Liu 2020) at the city level. On the other hand, it is a fact that in Japan, not only large cities but also the whole country could hardly cope with the digital response of temporary benefits and project subsidies for COVID-19 measures. Although it is only the personal opinion of the authors, the reason for this situation is that each of the various fields took individual empirical and experimental approaches and then tried to expand them horizontally. In other words, it was the result of years of vertical division, departmentalism, and departmental optimization since the Meiji era (the era that began in 1868, when the feudal era under the Tokugawa shogunate ended and a modern political system from the West installed was introduced). Therefore,

the Super City National Strategy Special Zone is a national strategy to create a few advanced examples (super cities) in Japan, open up the system (urban OS, etc.), and expand it horizontally from the beginning, or simply put, make many cities imitate it. In this section, we will review the efforts of Maebashi City in Gunma Prefecture, which is accelerating its efforts to realize such a Super City.

5.4.2 Background of the Super City Concept of Maebashi City

Maebashi is a medium-sized city in Japan with a population of 340 hundreds, located on the outer edge of the Tokyo metropolitan area, one hour northwest of Tokyo by train. It is also the capital of Gunma Prefecture. The city has been promoting itself as an "advanced city of education and medical care" because it has six universities and more than 30 vocational schools, one doctor for every 200 people, and one of the largest numbers of advanced medical facilities among medium-sized cities in Japan. In addition, although the city is located in the Tokyo metropolitan area, it is rich in nature due to its location on the outskirts of the metropolitan area, and it is also the birthplace of Sakutaro Hagiwara, a famous Japanese poet, so it has been promoting itself with the phrase "a city of water, greenery, and poetry." However, the reality is that just because of its proximity to Tokyo and abundance of nature, it is no match for cities where the Shinkansen or the bullet train stops in terms of convenience and corporate advancement. It has long been pointed out that not only in Maebashi but also in all regions of Japan, cities with Shinkansen stops have an economic advantage over other cities (Murayama 1994).

Therefore, Maebashi City has been promoting futuristic policies, smart city promotion, and city planning for public–private co-creation, aiming to become a "city of new value creation in collaboration with the private sector" and become a city that attracts creative people and companies as well as the corporate sector, referring to Portland and Seattle in the United States (Ito et al. 2019). In particular, in the area of co-creation between the public and private sectors, the Maebashi Vision "Mebuku" ("Sprouting" in English) was created by commissioning the KMS team, which is responsible for branding Porsche and Adidas in Germany, to create a vision at the initiative of the private sector. The activities of industry, government, academia, and citizens that support this vision have led to the realization of a number of projects, including the "Taiyou-no-kai" ("Sun Association" in English), "Taiyou-no-kane" (Sun Bell), "Hotel Project," and "Restaurant Project." In particular, the "Taiyou-no-kai" (Taiyou-no-kai 2021) is a system that is unique not only in Japan but also in the world. The association is a group of representatives of 24 business organizations related to Maebashi City who invest 1% of their company's net profit, or at least 1 million JPY, to create an edgy city. By collaborating with Maebashi City, the association has so far entered into city development projects such as the restoration and installation of the Sun Bell, a work by world-famous artist Taro Okamoto,

to make it a symbol of the city, and the implementation of road works that would normally be done by the city.

In parallel with the above-mentioned public–private co-creation of urban development, the promotion of "futuristic policy: smart city" is being promoted. The futuristic policy that served as the basis for Maebashi's Super City concept is the promotion of EBPM using public–private big data by the "Super Smart Local Government Research Council," an organization formed by Maebashi City, the University of Tokyo, Tokyo City University, Teikoku Databank, and Mitsubishi Research Institute. The council was established in November 2017 and selected as an MLIT Smart City Model Project in May 2019 (MLIT 2017) and as a MIC Regional Revitalization Award Encouragement Award in February 2020 (MIC 2020).

The Council's approach to EBPM is as follows. In the past, urban problems in Japan were mainly simple problems that could be solved by means such as putting an adhesive bandage on a wound, or complex problems that could be broken down into factors even if they were large in scale. However, in recent years, complex problems that we have never experienced before are becoming apparent, such as the problem of vacant houses, population decline, and the pandemic of COVID-19. It is difficult to create effective policies for these problems by relying on the traditional stove-piping, departmentalism, or the intuition, experience, and assumptions (KKO) of those with the loudest voices. In order for various stakeholders to actively participate in the difficult and complex regional issues described above, it is essential for them to "eye alignment" and "fostering of conviction sense" among themselves. In order to achieve these goals, we need evidence that will convince everyone, and that is exactly what EBPM is all about. In addition, in order to realize EBPM as described above, industry, government, and academia are collaborating and sharing their technologies and knowledge, actively utilizing the MGD held by the public and private sectors and collaborating with the public and private sectors to establish the necessity of promoting EBPM with actual examples, and to develop it horizontally.

The above concept is exactly the realization of Society 5.0 in local governments and can be called a fusion of digital and real. The Maebashi Super City concept is based on the realization of a scheme in which PDCA, which is much faster than before due to the fusion of the digital and the real, or "digital twin," and PDCA on a smaller scale are implemented simultaneously and in parallel.

5.4.3 Overall Picture and Challenges of the Super City Concept in Maebashi City

Figure 5.3 shows the overall image of Maebashi's Super City concept. The theme of this concept is named "Maebashi Mebuku Ground Concept." The main concept of the project is "Super City × Slow City," with the goal of "creating a city where diverse people are connected, learn, and grow throughout their lives, and create new values. Through "regulatory reform and digitalization" by super cities, we will realize a slow

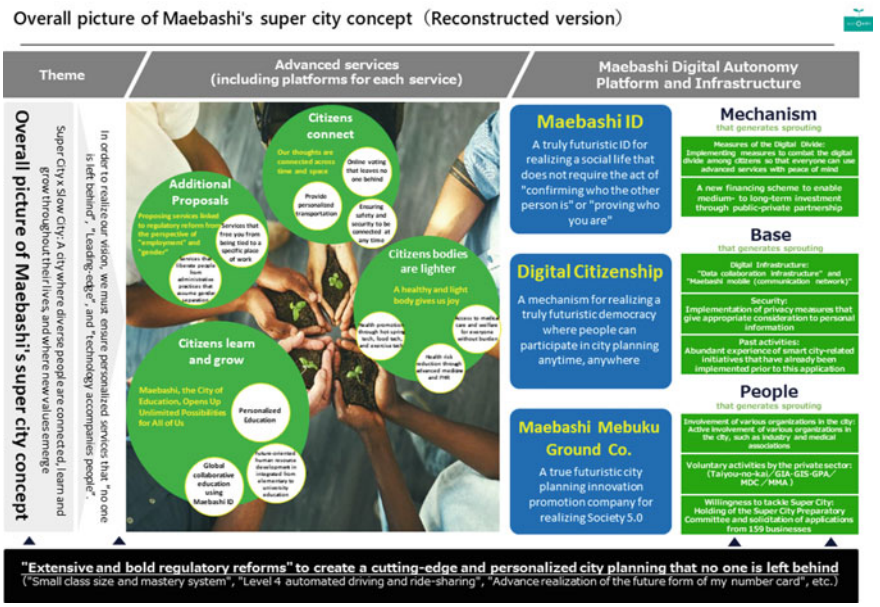

Fig. 5.3 Overall picture of Maebashi's super city concept (Maebeshi City 2021)

city, in other words, a city where "differences through diversity become richness. The term "slow city" here does not refer to the so-called slow country life. A "slow city" is a city that tries to realize a truly diverse society, where "diversity is wealth and diversity is power" (Farelnik and Stanowicka 2016). Of the 236 cities in 30 countries around the world that are members of Slow City, only two cities in Japan (Maebashi city and Kesennuma city) are members. In recent years, many people no longer distinguish or discriminate against people with "disabilities" or "LGBT." Slow City is an attempt to realize a society in which people with these various attributes are recognized as "enriched by their presence." In other words, Maebashi's super city concept is trying to realize a truly diverse society where people can recognize that "difference is richness" through the regulatory reforms and digital power associated with super cities.

So how can we achieve this society? Maebashi City is trying to answer this question with "no one is left behind" and "personalized (individual optimization)" services. In order to realize this vision, platforms are important, and in Maebashi City, these include the "Maebashi ID," Japan's first futuristic ID, "Digital Citizenship," which allows people to reflect their will anytime and anywhere, and the "Maebashi Digital Civic Autonomy Platform" by Maebashi Mebuku Ground Corporation, an organization in which the city owns 51% of the shares and which is promoted through a public–private partnership. In addition, Maebashi City plans to develop the following platforms and infrastructure: Maebashi ID with a legal basis, distributed

data collaboration, advanced privacy security measures linked to cutting-edge technologies such as insurance based on risk analysis, a new finance scheme in local governments that introduces private capital and shifts from a budget planning and execution principle to a performance-based system, measures to combat the digital divide to ensure social accessibility and eliminate mental barriers in addition to basic support such as smartphone distribution, Maebashi mobile information network in which the city will develop an information network mainly for education and medical administration, and so on.

As for future challenges, this concept will of course be difficult to realize only through the cooperation between the national government and Maebashi City, as it has been in the past, so it must first be shared and sympathized with various stakeholders, especially local citizens. Therefore, as of April 2021, when the Japanese government issued a public call for applications for the Super City, 159 businesses registered to participate in Maebashi's super city concept, and the city planed to further increase the number and quality of registered businesses and strengthen cooperation with them. It is also necessary to collaborate with local governments that are willing to implement the above concepts. In other words, it will be important in the future to deepen cooperation with related businesses, local citizens, and local governments in order to promote DX in the lives of citizens while building on the city's DX with an eye to the new future. Maebashi City will accelerate its efforts to lead other municipalities in Japan as a prototype of the super city.

5.5 Maebashi City's Approach to EBPM Using Municipal MGD: An Example of Estimating the Spatial Distribution of Vacant Houses

Prior to the aforementioned super city concept in Maebashi City, the Super Smart Local Government Research Council has begun working on EBPM using municipal MGD. Therefore, in this section, as an example of the Council's EBPM efforts using municipal MGD, we will introduce its efforts to estimate the spatial distribution of vacant houses using municipal MGD. Currently, the number of vacant houses in Japan continues to increase throughout the country. The increase in the number of vacant detached houses, especially those that have become unmanaged, can have serious consequences for nearby residents and eventually the entire community, such as the outbreak of fires due to arson, deterioration of public safety due to the intrusion of suspicious people, the risk of collapse due to aging, and deterioration of the landscape (Han 2014). It is also a serious problem that may lead to a decline in the vitality of the community and a drop in tax revenue for the local government, thus increasing the need for proper management of vacant houses.

The number of vacant houses has been increasing in Maebashi City and understanding the current spatial distribution and predicting the future will be important information for making medium- to long-term urban and regional plans based on

evidence. In response to this problem, Maebashi City conducted a field survey on the distribution of vacant houses in the entire city area from 2016 to 2017, but it took a lot of time and money to conduct the field survey covering approximately 130 hundred buildings in the city. Furthermore, since the distribution of vacant houses keeps changing, it is extremely difficult to keep track of the latest distribution of vacant houses using a method that relies on field surveys.

Therefore, the council is researching a quick and inexpensive method of surveying vacant houses using municipal MGDs (Fig. 5.4) (Baba et al. 2021). First, we constructed a data set using Maebashi City's municipal MGDs, such as the Basic Resident Register, water usage data, and Property tax ledger, as explanatory variables, and the results of Maebashi City's survey of vacant houses as the objective variable. The data set was developed by spatial integration on a digital building map based on location information: address or longitude and latitude. Next, the characteristics of vacant and non-vacant houses obtained from this data set are trained by machine learning: a non-linear machine learning model that can handle explanatory variables including missing values called XGBoost, and a model to determine vacant and non-vacant houses for each building is constructed.

In addition, the method developed a model to estimate the distribution of vacant houses in α years from the features of vacant houses obtained from municipal data in a certain t year and verified the consistency with the results of the vacant house survey in t + α years. Assuming that the model is sufficiently accurate and that the trends in the mechanisms of the occurrence, distribution, and persistence of vacant houses do not change significantly over time, it is also possible to estimate the distribution of

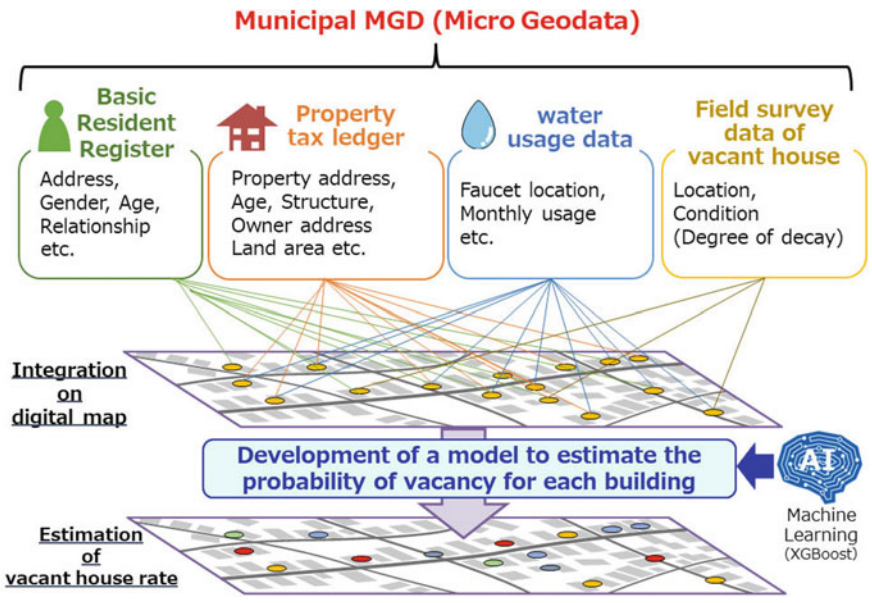

Fig. 5.4 Outline of this study

vacant houses any β years after a given year t, that is, from t + β to α years. In other words, the method can be extended to estimate the distribution of vacant houses in the future. The study predicted the status of vacant house distribution one year later (α = 1) using municipal MGD from 2014 (t = 2014) and verified the reliability of the prediction by comparing it with the actual field survey results of vacant house distribution conducted by Maebashi City (2016). The model assigns a probability of vacancy to each building in the range of 0–100% (Fig. 5.5), and by assuming that buildings with a probability of vacancy of 50% or more are vacant, the correct answer rate reached about 90%. We also applied this model to the municipal MGD of 2018 (β = 4) and compared it with the results of the 2019 field survey conducted by the council. When we assume that buildings with a vacancy probability of 50% or more are vacant, as, in the 2015 estimation, the correct answer rate is 72.5%, which is not as good as the 2015 results, but still a fairly reliable model. In addition, according to the importance of the features of vacant houses obtained from the model, the year of construction, building area, and building type were detected as important factors. These results are in line with the findings of many previous studies in Japan, and thus support the validity of our method.

As for future tasks, first of all, since this study only covers the central city of Maebashi, we are considering increasing the reliability of the model by expanding the target area and securing a sufficient amount of training data. This is an essential initiative for the future application of this model outside of the central city of Maebashi. In addition, since there were a few buildings in this study that were not assigned any municipal MGD, the problem of buildings that were not assigned any municipal MGD being excluded from the analysis became apparent. It is expected

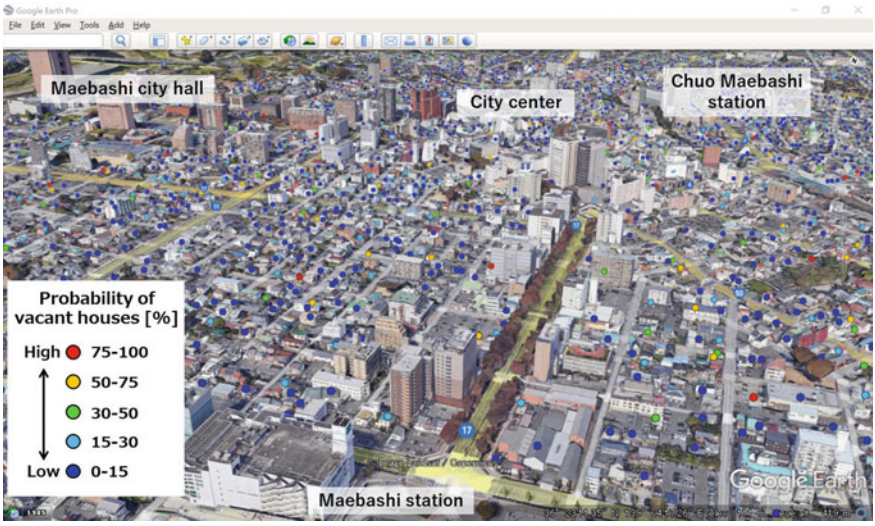

Fig. 5.5 Estimation result of the probability of vacant houses for each detached house in the central part of Maebashi City

that this problem can be solved by integrating other municipal data, private data, and various national statistics.

We are also currently verifying the versatility of this method by applying it to municipalities other than Maebashi City. We have already obtained analysis results in Wakayama City, Wakayama Prefecture (a local city with a population about the same size as Maebashi City) (Baba et al. 2020) and Kagoshima City, Kagoshima Prefecture (a relatively large city with a population of about twice that of Maebashi City) (Akiyama et al. 2020). The spatial distribution of vacant houses can be estimated with the same or higher reliability than in Maebashi.

Furthermore, we are conducting research in cooperation with the Maebashi City office in charge of vacant houses to determine what specific contributions can be made to policymaking and what further improvements are needed by regularly providing such high-resolution evidence of estimated vacant house distribution. In addition, we are developing a data visualization environment (dashboard system) to facilitate information sharing when sharing the results of these analyses with local government officials, as well as a tool that can be linked to the dashboard system to immediately reflect the results of field surveys (Fig. 5.6).

In this way, the Council's EBPM efforts in Maebashi City using public MGD are simultaneously collecting municipal MGD, developing new data, creating a visualization environment, collaborating with the section in charge of vacant houses, and verifying its versatility by expanding it to other municipalities. These activities cannot be realized by local governments, universities, or private companies alone, and it would not have been possible without the collaboration of industry, government, and academia. In addition, it is expected that cooperation with local citizens will become even more necessary in the near future. We hope that by continuing and improving these activities, it will become possible to formulate policies based on the realistic and serious evidence of municipal MGD, rather than copying "success stories based on local cases and experiences (episodes)," as has been the case with policymaking in Japan to date.

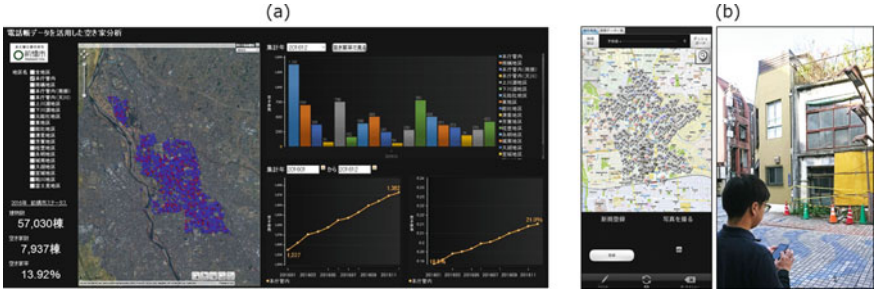

Fig. 5.6 A dashboard system under development in Maebashi City (**a**) and a field survey tool linked to the system (**b**)

5.6 Toward the Realization of a Super City Using Maebashi ID

In Sect. 5.4, we introduced Maebashi City's efforts to become a super city, and one of its most distinctive actions is the "Maebashi ID" (Maebashi city 2021). Maebashi ID is a future type of ID with legal basis and convenience (Fig. 5.7). By the combination of the digital certificate on the My Number card (Nakamura and Suzuki 2019), the authorized digital certificate that can be installed on a smartphone, and facial recognition, it will be a future type of ID with a legal basis that can be used for both government and private online applications (Fig. 5.8).

The fact that the Ministry of Internal Affairs and Communications (MIC) released its ministerial ordinance on the use of information and communication technology in September 2021, making it impossible to link private IDs and My Number cards, which was previously possible with a proviso, will ultimately increase the importance of this initiative. After the enforcement of this ministerial ordinance, it is expected that the government will be required to take measures based on the laws and regulations on which it is based, and the same will be necessary for online applications by the private sector. It is believed that online application systems will become essential in urban DX. In response to this situation, the demand for futuristic IDs that can be used by both the government and the private sector, that have a legal basis, and that are both secure and convenient will become higher and higher and will become indispensable for urban DX. Services based on futuristic ID: IDs which allows you to

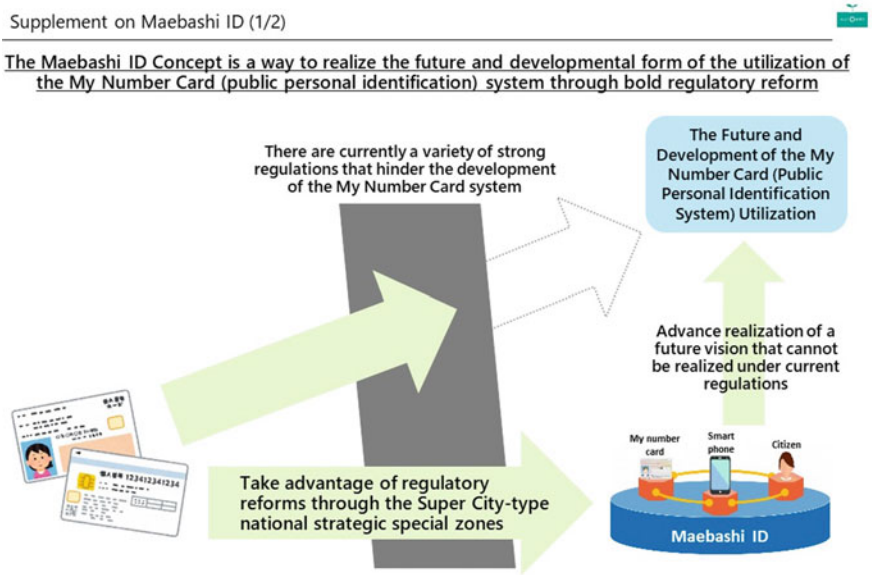

Fig. 5.7 Differences between Maebashi ID and My Number Card (Maebeshi City 2021)

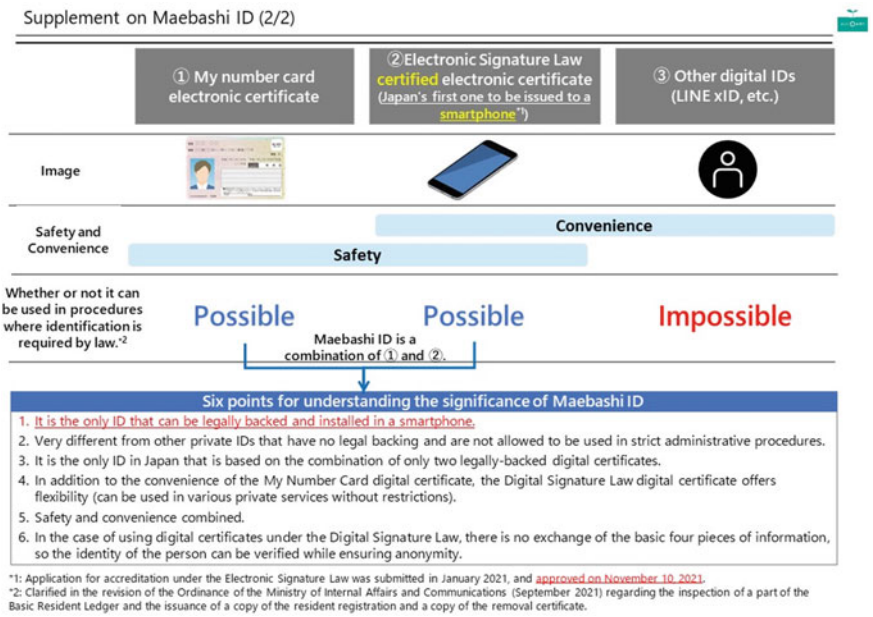

Fig. 5.8 Characteristics of Maebashi ID and points for understanding the significance of Maebashi ID (Maebeshi City 2021)

verify your identity and sign your name online, A system that allows people to check their own data and use the information they need when they need it based on their own consent, and IDs that can handle money DX including payments, are expected to enable efficient and attractive services in various fields such as education, medical care, transportation, disaster prevention and resilience, and so on.

We would like to reconfirm the essence of the above initiatives in Maebashi now. The essence of Maebashi's efforts is "urban DX," and the Super City is a means to that end. Maebashi City is aiming to be selected as a Super City by the Japanese government in order to promote DX in the city through regulatory reform and cutting-edge digital technology, but the city's policy is to proceed with the above initiatives regardless of whether or not it is selected as a Super City. In order to realize the above concept, the city applied and accepted for the "Construction of Maebashi ID and Services" in the Future Society Implementation Project of the FY2021 Smart City Subsidy Program, which was jointly implemented by four ministries (Ministry of Internal Affairs and Communications, Ministry of Economy, Trade and Industry, Ministry of Land, Infrastructure, Transport and Tourism, and Cabinet Office). As a result, it became possible to build a futuristic type of ID, "Maebashi ID," in cooperation with the national government, without being bound by the selection of a super city.

In addition, public–private partnerships with related technologies and knowledge are essential for the rapid social implementation of the above activities. There have

already been 159 business registrations in the public solicitation for businesses before the Japanese government's public solicitation for super cities in April 2021. In the near future, the city also plans to start business briefings and business registrations based on the explanation of Maebashi ID and its future development. Moreover, in collaboration with municipalities other than Maebashi City, the city started calling for the establishment of the "Association for Future-oriented Policies through the Utilization of Digital and Finance" in October 2021, which is a council of local governments, organizations, and businesses that are motivated regardless of region, based on cutting-edge digital technology and financing with the private sector, etc., and are preparing for the inaugural meeting in January 2022. By embarking on the above activities, the city plan to accelerate activities for the social implementation and further business development of services based on the Maebashi ID.

Furthermore, the most important factor in promoting the above activities is "empathy and sharing" with citizens. Compared to other cities, Maebashi is very advanced in communicating with its citizens. To date, the city has held 33 briefing sessions for the public and has had a total of 18,839 video views and other forms of intensive communication with the public. For example, the following efforts have been made: "Prospects through dialogue" through online meetings and citizen workshops, "Discovering issues from citizens' view" through questionnaires and workshops, "Momentum building" by distributing videos in collaboration with a private company that produces the most advanced viral videos in Japan, "Promotion of understanding" through public information sessions and open houses, and "Continuing dialogue with citizens" through town meetings and videos, etc. However, what is really important is not the number of briefing sessions or the number of video views compared to other cities, but how well the citizens understand the city's efforts. Since Maebashi City does not recognize that the current level is by any means sufficient, we believe that further "empathy and sharing" with citizens should be promoted. In order to implement the Maebashi ID, which is unprecedented not only in Japan but also in the world, it is essential to foster a sense of conviction among the citizens who will use this service most closely.

The realization of the Maebashi ID is one of the most important factors in realizing the "Super City x Slow City" concept. Therefore, in the future, we plan to realize activities that are truly beneficial to citizens, diverse, and advanced using Maebashi IDs by collaborating with various businesses and local governments.

5.7 Prospects for EBPM Promotion in Japan

This chapter introduced the concept of EBPM and the challenges of EBPM in Japan, as well as MGD, which is spatio-temporal high-definition spatial information useful for promoting EBPM. In addition, specific examples of MGD applications in the research field, Maebashi City's super city concept and its underlying EBPM concept, the development of a method for estimating the distribution of vacant houses using municipal MGD as part of Maebashi City's EBPM efforts, and the efforts of Maebashi

ID, a future ID with a legal basis, are introduced. In addition, we introduced the efforts of Maebashi ID, a future ID with legal basis.

Based on the above, this section concludes with a discussion of the future prospects for EBPM promotion in Japan. As Japanese society faces difficulties never experienced before, there is a growing need for sustainable community management in the face of limited financial and human resources. In addition, local governments need to deal with complex problems such as dealing with a declining population and vacant houses. These problems are not simple problems that can be solved by conventional remedies, nor are they complex issues that can be easily broken down into factors. In other words, they are complex problems that cannot be analyzed into factors and whose outcomes cannot be predicted. To solve such problems from the perspective of total optimization, rather than the traditional vertical divisional optimization, it is necessary to quickly build consensus among various stakeholders, including citizens, based on quantitative evidence, while understanding the present state of the municipality and looking to the future. In order to realize this, we need the "EBPM" that examines and promotes policies based on evidence, rather than the "KKO" that is still prevalent in the Japanese government. To realize EBPM in Local Governments, we will require technologies to collect and analyze MGD, the creation of a visualization environment (dashboard system) to promote understanding of the results of the analysis, and the operation of a futuristic ID that will serve as a tool to provide citizens with quick and diverse services. In addition, to realize these goals, it is essential that industry, government, academia, and the private sector work together and mobilize their respective strengths, rather than the city working alone.

What is important to accelerate the above activities in Maebashi City and to expand them to other municipalities not only in Maebashi City but also in Japan and the world? Of course, it is also important for Maebashi City to take the lead in creating many successful cases. This is because, at least in Japan, precedent-setting is prevalent in many local governments (Ishihara 2021), and the structure makes it easy to introduce new initiatives if there are successful cases in other local governments. However, this alone may be a limitation for rapid and large-scale horizontal deployment.

Therefore, we believe that it is necessary to change the mindset of national and local government officials. Here, we would like to propose the following three points. The first point is that for Japanese civil servants in the past, "the whole" meant what "each department" of the government or office did. However, this way of thinking did not allow us to think about issues that crossed departments and required total optimization, and we were unable to clarify the essence of the issues, resulting in a situation where "we were looking at the trees and not seeing the forest." However, until now, they have not had the time to think about the big picture because of the need to perform daily operations with limited resources. However, it may be possible to create this margin by improving the efficiency of operations through DX and by introducing the latest technology through active collaboration with the private sector and universities. With this margin, they will be able to do "Futuristic Thinking", which is total optimization with an eye on the future of their local government. In order to give this kind of margin to the staff, it is important to have the idea

of active introduction of DX by the local government and collaboration between industry, academia, and government. In addition, it is hoped that by having not only local governments but also companies and universities work together to think about how local governments should conduct DX, completely new ways of thinking and combining ideas will emerge that are not extensions of conventional thinking.

Second, it is important to know how many people will be able to do "Mind Shift" as a result of DX. First, the Mind Shift of local government employees needs to shift. It is important that they think in terms of streamlining their existing work and optimizing it as a whole, rather than increasing their workload through DX. If they cannot do this Mind Shift, there's not much point in the DX. At the same time, it would be ideal if the companies, universities, and residents involved in that municipality also do Mind Shift. In particular, the Mind Shift of citizens is essential. This is because even if a municipality implements an advanced and useful system such as the Maebashi ID in society, citizens will not be able to benefit from it unless they use it. In order to achieve them, it will be difficult for urban DX technology like the Maebashi ID to penetrate the population unless the local government officials first achieve the above mindset shift.

Third, in order to achieve the above-mentioned total optimization, it is important for local government officials to have the "conceptual and breakthrough ability." The conceptual and breakthrough ability for local government officials here refers to a mindset that can identify individual issues that need to be addressed now to realize the overall goal of "creating this kind of society" and move quickly to resolve them. And to realize this, it is important to know how to connect technology and vision, and how individual technologies can be connected to the vision. In order to acquire such knowledge, it will be necessary for industry, government, academia, and the private sector to learn about each other's latest situations through collaboration, and to create opportunities for relearning (recurrent education) at universities and vocational schools when necessary.

Various schemes, ideas, and data for realizing urban DX, such as smart cities, EBPM, super cities, futuristic ID, and MGD, are coming together now. However, no matter how many great technologies and rich data we prepare, in the end, the most important thing is "Human". The future of Japan's local governments depends on how industry, government, academia, and the private sector can achieve the "Mind Shift" toward DX, and how they can nurture human resources in their communities who have both the "Futuristic Thinking" and the "conceptual and breakthrough ability. In the near future, cities that can achieve not only DX but also HX (Human Transformation) will be able to become truly sustainable and attractive cities. The authors are convinced that the title of this chapter, "Evidence Based Policy Making of Smart City," can be realized by HX. We will have to keep a close eye on Maebashi City in the future!

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Chapter 6
Personal Life Records for Health Decision-Making in Disaster Situations Society 5.0 and Implications for Resilient Community

Naonori Kato, Sakiko Kanbara, and Akira Morita

Abstract The importance of disasters and personal information has long been pointed out. Still, these are discussions based on the necessity of each situation, such as preparing a list of people requiring support as an advance response, issuing disaster survivor certificates, and publicizing missing people and dead people, and no systematic approach has been taken. However, in the wake of a series of natural disasters, there have been numerous issues raised concerning the issue of personal information. The information infrastructure that utilizes the data is necessary to use the data so that AI and machine learning can collect enough data. It is also essential for the institution for data usage. This chapter summarized the fieldwork and case study targeting the flood disaster in the Mabi district of Kurashiki City, Okayama Prefecture, on July 7, 2018, using personal information as an approach and its successor work. Meanwhile, in Europe, the European Commission has floated the idea of "data altruism" as it considers data governance legislation. The new notion throws a stone at traditional data protection, and it also has implications for the use of personal information in disaster prevention. This chapter identifies the most serious problems in utilizing personal information in disaster prevention and introduces the concept of data altruism proposed as a solution.

Keywords Personal data · West Japan Flood 2018 · Altruism · Personal information protection law · Act on the protection of personal information

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6.1 Introduction

As exemplified by terms such as IoT, AI, and machine learning, it is expected that society will undergo a significant transformation using accumulated data and information processing technology. Society 5.0 is an example of this, and attempts are being made to solve various social problems by obtaining exceptional knowledge through large-scale machine processing as big data that accumulates a large amount of information using networks. The Japanese government's "Japan Revitalization Strategy" calls for reforming the industrial and employment structures through IoT, big data, and AI. In the Fifth Science and Technology Basic Plan, machine learning (Sometimes called AI) focuses on realizing large-scale machine processing efficiently (Cabinet Office 2021). As the use of AI and machine learning brings about a significant change in society, discussions are being held on the institutional side in preparation for the full-scale use of AI and machine learning. Major discussions were held at the AI Network Society Promotion Council. Released a report in July 2018, the council analyzed the social and economic impacts of AI networking. It developed a draft of principles for the use and application of AI, establishing guidelines as a future task (Ministry of Internal Affairs and Communications 2018).

On the other hand, our country has seen many large-scale natural disasters in recent years. Looking at past disasters, it becomes clear what needs to be prepared for handling personal information. The importance of disasters and personal data has long been pointed out. However, these are discussions based on the necessity of each situation, such as preparing a list of people requiring support as an advance response, issuing disaster survivor certificates, and publicizing missing people and deceased people, and no systematic approach has been taken. Nevertheless, in the wake of a series of natural disasters, there have been numerous issues raised concerning the issue of personal information. Therefore, a research group, including the author, conducted a survey targeting the flood disaster in the Mabi district of Kurashiki City, Okayama Prefecture, on July 7, 2018, using personal information. As a result, it became clear that there were substantial problems with the list, which is the key to identifying damage and providing support in a disaster. In other words, AI and machine learning cannot collect enough data.

The European Commission has floated the idea of "data altruism" as it considers data governance legislation. It throws a stone at traditional data protection. It also has implications for the use of personal information in disaster prevention. In this chapter, the most serious problems using personal information in the disaster prevention field are identified, and the introduction of the concept of data altruism is proposed as a solution to these problems.

6.2 Issues of Information Sharing During Disasters

6.2.1 Personal Information as the Basis for Information Sharing and Cooperation

How should information sharing and cooperation be carried out in a disaster? The most important thing and the starting point of disaster countermeasures are how to grasp the needs in a disaster. Various existing measures utilize macroscopic information such as open data and big data. However, it is difficult to provide relief to each survivor of disasters. In addition, although various systems have been proposed, the connectivity between systems is not guaranteed. Although disaster response guidelines and manuals are developed for each department and office, there is no shared awareness of the functions of the office in information sharing. From another perspective, if personal information can be managed appropriately, it is possible to understand needs in a disaster and provide optimal support accurately. It is crucial to organize how to protect individuals in a disaster and what personal information is required to meet the purpose of disaster response. However, there is a problem that even expected lists such as the list of people requiring support for evacuation activities, the disaster survivors' register, and the shelter list cannot be coordinated.

6.2.2 List of People Requiring Support for Evacuation and Disaster Survivor Register

The lists of people requiring support for evacuation activities and the disaster survivor registers are public lists maintained by local governments. The following is an overview of each of them.

In the revision of the Disaster Countermeasures Basic Act in 2013, the following provisions were established to implement effective evacuation by expanding the list of people requiring support for evacuation activities.

(1) Require municipalities to prepare lists of people requiring support for evacuation activities and make it possible to use personal information necessary for such preparation.
(2) Providing information to people concerned with evacuation support, such as fire departments and welfare commissioners, from normal times with the consent of the person in need of evacuation support.
(3) If a disaster occurs or is likely to occur, the list information may be provided to people concerned with evacuation support or others without the people's consent.
(4) Obligation of confidentiality shall be imposed on people who have received list information, and municipalities shall take necessary measures to prevent the leakage of list information.

The "Guideline for Evacuation Support for people Requiring Assistance in Times of Disaster" was revised in response to this revision. It is stipulated that municipalities, primarily local governments, should refer to this guideline when carrying out their duties Cabinet Office (2013). In addition, the "Guideline for Support for Evacuation Activities by people Requiring Support for Evacuation Activities" indicates the necessity for primary local governments to prepare in advance and provide evacuation support promptly to limit the casualties requiring support for evacuation activities, such as elderly people requiring care and people with disabilities, and people related to evacuation support. The Disaster Countermeasures Basic Act stipulates that municipalities prepare lists of people requiring support for evacuation activities (Article 49, 10) (e-gov 2018).

On the other hand, in revising the Disaster Countermeasures Basic Act in 2013, the administrative work related to the preparation, use, and provision of disaster survivor registers was newly stipulated by Cabinet Office (2013). In conjunction with this revision of the law, administrative work related to the creation of disaster survivor registries was added to the scope of My Number usage (Act on the Use of Numbers to Identify a Specific Individual in Administrative Procedures, Appended Tables 36 (2) and 56 (2)). It was decided that the local government should prepare the disaster survivor register and carry out the work using My Number related to the disaster survivor register.

It was decided that municipalities should conduct studies in peacetime so that disaster survivor registries can be smoothly prepared after disasters and that comprehensive and efficient assistance can be provided to disaster survivors, taking into account the characteristics and actual conditions of the area. Concerning operations related to support for disaster survivors, which are carried out from the period of emergency disaster response measures to the period of recovery from disasters, it is not uncommon that assistance is not adequately provided to disaster survivors who are eligible to receive benefits because the number of disaster survivors is immense at the time of a large-scale wide-area disaster. Employees of local governments who have little experience in disasters are not necessarily familiar with operations to support disaster survivors because disaster survivors' locations and contact information are not shared. To prevent such situations and implement proper support efficiently, the "Practical Guideline for the Preparation of Disaster Survivor Registers" explains what to prepare disaster survivor registries that unitarily summarize the state of damage suffered by individual survivors, the state of implementation of support, matters to be considered when providing support and the like, and to share and utilize these registries among related departments of disaster-affected organizations. For example, in rapid preparation for the disaster survivor registries, information held by each department can be stored in a system for supporting disaster survivors from ordinary times and updated as necessary. The guidelines explain that municipalities can prepare disaster survivor registries as a "basis for providing support for disaster survivors."

6.2.3 Evacuation List

We conducted hearings on the list of evacuation centers for NPOs, volunteers, and disaster survivors who provided support in the area. The results are summarized as follows:

There were two staff members from the Kurashiki City Hall at each evacuation center. These employees obtained an "Evacuation center user registration card (After this, the acceptance form)" at the reception desk of the evacuation center. In the application form, names, addresses, contact information of each family member, conditions of their homes, places where they wished to stay, injuries, illnesses, disabilities, allergies, pregnancies, languages, matters requiring special consideration, special skills, and licenses, and appropriateness of disclosure of safety confirmation information were collected. These lists were kept only by city hall staff at the reception desk and were not provided to NPOs. The list was also not shared with healthcare providers (At DMAT, some said that the list was provided, but others said not, so the investigation is currently underway.). NPOs that could not receive the application forms were required to create their lists, and they went around to the disaster survivors in the evacuation centers one by one to collect information. Since different NPOs could not share lists from the viewpoint of protecting personal information, each NPO created its list (multiple lists existed in one shelter). There was also the problem of updating the list. When disaster survivors engaged in reconstruction work during the daytime, they sometimes fell out from the updated list. For example, in surveying the number of necessary items such as food and clothes, there were cases where these survivors were not included in the list; thus, goods were in short supply.

6.2.4 How to Associate the Three Lists

Since the revision of the Disaster Countermeasures Basic Act in 2013, local governments have been preparing lists of people requiring evacuation support and disaster survivor registries. While these lists have been put in place, questions remain as to whether the local governments have been able to fulfill their role in evacuation centers. From the perspective of post-disaster assistance, it is no exaggeration to say that the list of evacuation centers plays a more significant role than the other two lists. The creation and organization of the list in chronological order showed that the list of people requiring support for evacuation activities was prepared before the disaster, nor was the disaster survivor register prepared before the disaster. The list of people needing support and the disaster survivor register functioned only after the flag of "disaster" was raised. Looking at the case of the Mabi district, the most effective equivalent of these flags seemed to be the receipt for the evacuation center.

In the list of people who need support for evacuation activities, not all people are required to receive support. It is necessary to appropriately grasp the people who need support after the disaster. In addition, it is critical to learn who needs to be

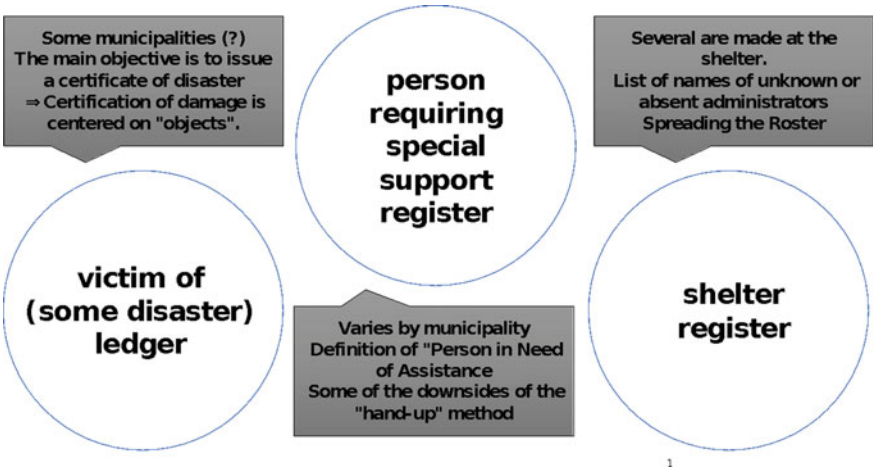

Fig. 6.1 Relevance of the lists

issued a disaster survivor certificate, for example, in the disaster survivor register. The application form of the evacuation center is most likely the quickest way to learn who was actually "damaged" in the disaster survivor register. However, the local government may know who can be included in the disaster survivor register. Lists of people requiring support for evacuation activities and the disaster survivors' record (the basic ledger) are useless by these lists; they cannot function without a flag indicating who was affected by the disaster. Based on the residents' opinions, the acceptance status of evacuation centers could be one of the flags. Figure 6.1 shows the relationship between these three lists.

Additionally, Fig. 6.1 also shows the problem of lists by each local government. In other words, it is not always clear whether each municipality shares the lists. This uncertainty also leads to how to deal with a disaster when the disaster-stricken area spreads across municipalities. Moreover, an individual's living area is not necessarily limited to the municipality to which the individual belongs. A person may be affected by a disaster while away from home. Then the question arises as to whether these three lists would function when an individual is in such a local government.

How can we solve this problem with these lists? First, as mentioned above, cross-border information sharing is vital in a wide-area disaster. Such a system will be required to supplement an individual ID even across borders. If the system is not designed to identify individuals associated with each list, the necessary support may not be delivered due to delays or omissions in providing information to individuals.

6.2.5 *Case Study: Machi Care Commons*

During emergencies and disasters, sanitation systems and hygiene facilities, and residents' healthcare facilities are limited, growing the risk of water-borne and vector-borne infections. Food security is also essential; undercooked food can cause illness. As a result, undernourished people are more exposed to communicable and non-communicable diseases and are vulnerable to the physical burden of all infectious diseases. Besides, people with disabilities are less likely to receive the help they need during humanitarian crises and less likely to recover long term. General experience has shown that people with disabilities are more likely to be left behind or abandoned in disaster evacuations due to a lack of preparedness and planning, inaccessible facilities and services, and transportation. Most shelters are not available, and people with disabilities are often even turned away from shelters because of their perceived need for complex medical services. Under these circumstances, the availability of so much data and information during a disaster can be overwhelming if healthcare providers lack decision-making skills. It should be purposefully designed to demonstrate responsibility for addressing human security in their actions and the development of national evacuation plans (Fig. 6.2).

During COVID-19, as an improvement to the feasibility study, one prototype of an interactive health monitoring application that communicates and provides relevant information in real time was developed and released in Japan. This mobile application includes personal disaster evacuation action plans, location information through geotagging capabilities, and online mapping of community information. The

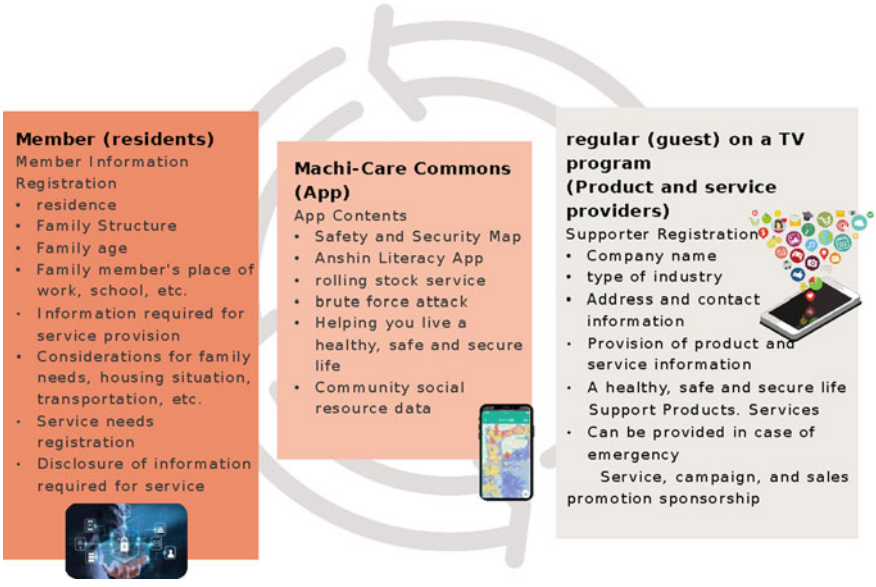

Fig. 6.2 Cycle of personal life record for disaster risk reduction behavior

information means community health data consisting of location and time stamps of indicators, structured text data, and geotagged photos. This data can be converted into anonymous open data for crowdsourced community risk mapping. To ensure health during emergencies, we could collect health data and shelter information (e.g., location, timestamp, and geotagged photos). However, a clause wind is needed to actively encourage people to update the information.

In general, many different organizations are involved in people's health care. It is not uncommon for patients to receive treatment at multiple medical institutions during the same period. Care needs to be taken in handling the data of such patients. Medications prescribed by other medical institutions cannot be recognized as concomitant medications. If a patient is admitted to another medical institution or dies in another medical institution, it is impossible to evaluate the patient using only data from their institution. The data registered as basic patient information and profiles vary greatly depending on the hospital's information system. In an increasingly diverse society, standardization of data is becoming increasingly difficult. It is not easy to obtain basic patient information and profiles from various information systems. These problems could be solved by introducing unique IDs and creating a research environment using those IDs. In the medical field, the data to be acquired is stored as structured data by describing the examination items using templates. The support person observes, selects, and inputs the data, but more detailed and timely data can be obtained for oneself if this can be done with self-care. In addition to blood pressure, pulse rate, smoking history, drinking history, and the like, which are necessary for personal management, records of people's life reconstruction can also be used to understand the situation through text mining if there is a way to document and organize the contents and also grade them. From this perspective, it is also vital to promote the secondary use and operation of data to be analyzed by gender and find alerts for high-risk people and threats to human security. The system can also reduce the time and geographic burden of rapid health crisis management and care operations in hospitals. As applied to systems, this concept of interoperability reduces redundancy in recording information, making data processing more efficient and consequently enabling data-driven decision-making. It also leads to social innovation for social inclusion as it allows data to be created across differences in language, culture, religion, and beliefs (Fig. 6.3).

6.2.6 Consensual Bias

As a means of protecting personal information, it is generally said that obtaining "consent" is the key. The idea is that a person handling personal information can legally use personal data by obtaining the consent of the person who is the subject of the personal data. In disaster prevention, too, there is an emphasis on consent. In the list of persons in need of support for evacuation activities, consent is required to provide information to people concerned with evacuation support, such as fire engines and welfare commissioners from normal times. Some local governments

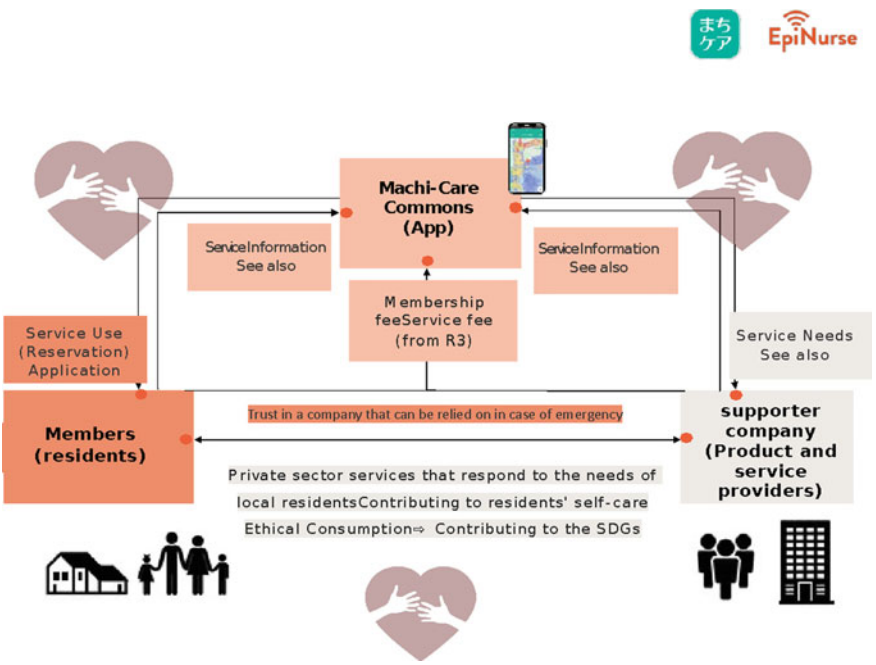

Fig. 6.3 Mutual assistance model using personal record in primary health care approach

require consent to list such people in the first place. Another reason why the list of shelters is not shared with supporters is that consent cannot be obtained. In the first place, it is not realistic to obtain consent in situations where it is impossible to contact the person in question, such as in a disaster. While there is a role of consent for personal involvement, the downside of expecting too much of a personal protection role must be considered. In other words, the protection of personal information should not lead to neglect of personal safety.

6.3 Proposals for Data Altruism in Europe

6.3.1 Data Governance Bill

On November 25, 2020, the European Commission released the Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European data governance (Data Governance Act), based on the "A European strategy for data" published on February 19, 2020 (European Commission 2020). The bill aims to ensure the safety of the processing and reliability of data sharing and to promote data sharing between the public and private sectors. In this context, the

term "data altruism" is used to describe the use of data for public benefit. Before and after the data governance bill, data altruism is actively cited in the European debate and is seen as a new way of utilizing data.

The Data Governance Bill introduces data altruism in Chap. 4. This promotes data altruism (data made voluntarily available to individuals and companies for public benefit). This allows organizations engaged in data altruism to register as "EU-recognized data altruism organizations" to increase confidence in their activities. In addition, a joint European data altruism agreement will be developed to reduce the cost of consent collection and promote data portability (when the data to be made available is not held by individuals).

However, these explanations in the bill do not fully explain what data altruism is.

6.3.2 Data Altruism in Health Care

On the other hand, on February 1, 2021, the European Commission published the "Assessment of the EU Member States' rules on health data in light of GDPR" (European Commission 2021). This study examined the impact assessment of healthcare data under the GDPR, including developing national laws in member countries. It aims to investigate possible differences between the EU member states and identify factors that may affect the cross-border exchange of health data in the EU for medical, research, innovation, and policymaking purposes. Data altruism is cited in the report as an important factor.

Chapter 7, Strategies and Entities for Data Governance, refers to data altruism. Special focus is given to the secondary use of data, defined in the report as function 2 and function 3. National agencies or bodies are already qualified to grant authorization to use data collected for other specific purposes. Other mechanisms to provide access to health data for research and public policy purposes, including through initiatives to further strengthen data altruism, are under consideration. This will help to identify possible options for improving the effectiveness, efficiency, and consistency of systems to provide access to data for secondary use and to draw recommendations for further action at the EU level to support access to health data for secondary use in the context of the creation of future European health data spaces, as set out in the European Digital Strategy.

The report focuses on the reuse of data from sources such as EHRs, hospital information systems, and disease registries. These are well-established sources of health data for research, and codes of ethics have been adopted in many member states to ensure that they are used for research purposes. However, with the increasing use of personal health records, personal health spaces, and personal health and wellness devices and apps, it is explained that the concept of data altruism becomes relevant in addition to existing mechanisms for the further use of patient data for research based on the concept of public health and solidarity.

6.3.3 How to View Data Altruism

While the data governance bill alone is challenging to capture the implications of data altruism, the Commission's report provides a concrete understanding. On the other hand, as noted in the report, the data altruism explored in healthcare data may not be complete. The data altruism proposed in the Data Governance Bill is not necessarily appropriate for the use of healthcare data. Instead, examples of data altruism in the use of healthcare data are not based on the idea of data altruism but are data altruism resulting from the pursuit of social use of healthcare data.

Such a view of data altruism may also be valid in disaster prevention. Therefore, the following two examples are introduced to examine the validity of the data principle.

6.4 Examination of Specific Cases

6.4.1 Personal Information Protection Act 2000 Issues: Information Sharing Issues

The 2000 issues related to the legal system for the protection of personal information refer to the fact that in addition to private business operators, national administrative organs, incorporated administrative agencies, local governments (such as prefectures, municipalities, regional federations, some administrative associations) all over the country have their own rules governing the protection of personal information. There are approximately 2000 such rules independently. The Act on the Protection of Personal Information (after this, the Personal Information Protection Law) stipulates the basic principles and the role of the national government. However, different regulations mentioned above are established for entities other than private business operators depending on the entity that holds personal information. Regarding the 2000 issues, it has been pointed out that there are many variations in the regulations and each has its authority for interpretation. In addition, it has been pointed out that there is also a problem that there is a time difference in the reflection of the rules because each disciplinary body has to revise the rules in conjunction with the revision of the Basic Law.

Figure 6.2 shows one aspect of the 2000-point problem. The figure summarizes whether each prefectural government's information protection ordinance has a clause that excludes the use of personal information for academic research. Approximately 1/3 of local governments do not have such regulations. For example, some initiatives in the medical field use personal data based on exemptions for academic research purposes. National university hospitals and public hospitals sometimes exchange personal information in these efforts. Among the municipalities shown in Fig. 6.2, even if a hospital established by the municipality with a "no" regulation wishes to exchange personal information for academic research use, it cannot do so because there is no such regulation.

6.4.2 *Safety Issues: Information Disclosure Issues*

Confirmation of safety in the event of an accident or disaster has long been taken up as an issue. For example, in the case of the derailment accident on the JR Fukuchiyama Line on April 26, 2005 (JPCERT Coordination Center 2008), the railway operator refused to confirm the safety of some passengers on the grounds of the Act on the Protection of Personal Information. It is also pointed out that many local governments did not disclose personal information after the Great East Japan Earthquake on March 11, 2011. It is also known that during the flood disaster in Joso City, Ibaraki Prefecture, due to the heavy rain in the Kanto and Tohoku regions in September 2015, information on the safety of the missing people was not promptly shared, which disrupted search activities.

Such sharing of safety confirmation information cannot be conducted smoothly, due in no small part to the 2000 issues pointed out earlier. First of all, in many cases, such safety confirmation information is first grasped by each local government. This will depend on the regional disaster prevention plan, but each local government will have its disaster response headquarters, where information will be integrated. In addition, the rules applied to rescue activities at disaster sites are different because the organizations of fire departments are different from municipalities, police departments from prefectures, and the SDF from the national government. If the rules that apply to each of them do not include, for example, emergency response provisions or exemptions for news reporting purposes, it would be difficult for each entity to determine whether it can uniformly provide such provisions. Alternatively, even if each rule has these provisions, since each party has the authority to interpret and implement the rules, the possibility cannot be denied that each party may make a different judgment even in a similar case (Fig. 6.4).

Fig. 6.4 Academic research related by prefecture: "Does it have provisions related to "academic research"?"

6.5 Consider Data Altruism: A Break from Consensus Parochialism

The use of personal information in a disaster poses a significant challenge, and the introduction of data altruism has the potential to address this challenge. Therefore, the possibility will be discussed below.

6.5.1 Validity of Data Altruism

Data altruism can dispel concerns about protecting personal information during disasters. Data altruism affirms the use of data for altruistic purposes without undue reliance on individual consent.

One possible embodiment of data altruism is in the United Kingdom. In the United Kingdom, national data opt-out was introduced on May 25, 2018 (House of Commons 2020). It is an NHS England/NHS Digital policy initiative that allows patients to opt out of using their data for research and planning purposes. NHS patient information may also be used to plan and improve health and care services and research and develop treatments for serious diseases. The local authorities, university and hospital researchers, medical schools, and pharmaceutical companies also use the information to explore new treatments. The national data opt-out applies, for example, when an organization such as a research organization confirms that the confidentiality advisory group (CAG) has approved the disclosure of confidential patient information held by other organizations responsible for data, such as NHS trusts (data controllers). CAG approval, also known as Section 251 approval, refers to Section 251 of the National Health Services Act 2006 (The National Archives 2006) and its current regulations, the Health Services (Management of Patient Information) Regulations 2002. NHS Act 2006 and the regulations allow for the temporary removal of common law confidentiality so that data controllers can disclose confidential patient information without violating common law confidentiality. In practice, this means that the organization responsible for the information (the data controller) can, if desired, disclose the information to the data applicant, for example, a research institution, without violating common law confidentiality. The opt-out applies only in these cases.

6.5.2 Move Away from a Consensus Bias

Given the benefits of analyzing data and the costs of not having access to it, a similar system could be built for disaster prevention. When a disaster occurs, it is essential to identify the disaster area survivors comprehensively. The hesitation in identifying the survivors and disclosing information on their safety due to the lack of consent has

resulted in considerable costs at disaster response sites. The challenges of information collaboration in September 2015 will be part of this. In a large-scale disaster, these not-insignificant costs add up to huge costs. Although we have avoided facing such a huge cost directly, we should redefine the issues and sincerely address them as we promote Society 5.0 and data utilization.

There are real benefits to being able to analyze data, plus the cost of not having data available. Society not only enjoys the benefits but also unknowingly incurs huge costs. There is no doubt that the cause of this is consensus bias. People should be aware of data altruism, move away from a consensus bias, and rethink what they want to protect. The answer is clear: do they want to protect their personal information, or do they want to protect themselves? People should put personal protection first. Therefore, the government should consider the possible protection of personal information.

6.5.3 How to Develop the Information Infrastructure, Interoperability

So what should people do to protect individuals? If they already have the necessary institutions, the next thing they need is the use of data. The information infrastructure is essential for the utilization of the data.

6.6 Conclusion

Demographic changes and crises create multiple imbalances in sharing both burden and demand in the short and long term. Areas that were neglected and under-reported included the risk management of these conditions in the community and the impact of delayed events and health problems outside the hospital. There is a need to promote universal access to health services for equitable health, the establishment of health-care systems, human-centered health services, human resource development, and global health on a global scale. The people most affected by the lack of universal access to health are those living in the most vulnerable situations.

These changes will have a widespread impact on how public services are organized and delivered, affecting the quality of people's lives. Before building such a platform, ensuring inclusiveness, sustainability, and user-friendliness is necessary to avoid creating thousands of merely digitized systems with no real change for healthy people. Since all development is market-driven rather than needs-driven, crisis management, infectious disease control, and public health in traditional governance tend to persuade majorities and averages rather than individual issues. There are concerns about the extent to which the needs of inclusive communities are taken into account. It is also important to note that fragmented data using ICTs and analytical

tools can generate a variety of targets within an inclusive community, as development, perspectives with defined characteristics such as communication, interdependence, early prevention, anthropocentrism, social cohesion, and stability are promoted globally. It is vital that residents actively participate and engage in human development, monitor environmental changes and social systems themselves, and share the correct information to design and build sustainable partnerships. It is necessary to design and build partnerships. To achieve the goal of interlinked participation and involvement in policy development and implementation processes and to achieve the goal of "evidence-based policy development," it is necessary to set goals for everyone, themselves, and others. Doing so will increase interest in program development, motivate capacity building, accelerate bottom-up participation activities, and increase the likelihood of adapting to what happens locally in the future.

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Chapter 7
Digital Transformation and Disaster Risk Reduction

Hiroyuki Miyazaki, Archana Joshi Shrestha, and Shoko Miyagawa

Abstract As the concept of Society 5.0 evolved over the last 4–5 years, it is important to analyze the key policy perspectives of the concept and its relation to developing intelligent and resilient communities. While health care, agriculture, and education are strong pillars, disaster risk reduction and addressing key social issues are also integral parts of the concept as a people-centered approach, which will be analyzed and highlighted in the chapter.

Keywords Digital transformation · Participatory GIS · Service design · ICT · Health monitoring

7.1 Introduction: What is Digital Transformation and How?

Digital transformation is a process of incorporating information and communication technologies (ICT) into existing operations for innovations. We can discuss digital transformation in three components—data, process, and users. It is expected to benefit in higher productivity of daily operations, usually automating some operations, and also information management in high-level decision-making, which are often called data-driven decision-making. The trends have emerged since 2000, when personal computers and the Internet broadly penetrated people over the world. Following the Internet penetration, smartphones have changed people's lives owing to higher accessibility to digital technologies. Nowadays, people are equipped with ICT devices and infrastructure. While some business operations have achieved great success in digital transformation, most of the people do not know or understand how to use

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those for changing their business and lifestyles. Digital transformation is the process for leaping the last miles to innovations.

Data originally comes from science, which is a way of research by hypotheses and observations. It is defined as individual facts, statistics, or items of information, often numeric (OECD 2000), so it helps precise understanding for solving problems. Therefore, data is the important origin of digital transformation, which aims for better business operations and people's lives. Although the term is often associated with "digital," data is not always in digital formats, also in analogue formats like notebooks. The major difference between analogue data and digital data is physical space per amount of information. An example showed that a single terabyte is roughly equivalent to 75 million pages (Brestoff 2010), and the gap in physical spaces is becoming greater along with the progress of digital storage technologies. The advantages have become more prominent recently in the era of big data. Google estimated that data is produced 20 petabytes everyday (Pence 2014), equivalent to 1,500 billion pages in papers… impossible! Digital formats of data contribute to the progress of digital transformation with big data.

Data needs to be processed for formulating useful information. The process includes techniques of data science and engineering, such as statistics and machine learning. The techniques are invented for providing data with meanings and semantics. However, the techniques do not automatically produce new meanings or semantics. We need to define meanings and semantics in data, which are usually called labeling. The important point of the process is definition of the meanings and semantics within data along with operations targeted by digital transformation. The process can target only a few meanings and semantics in the data and cannot capture all of meanings and semantics. Therefore, the process design has to carefully focus the most important aspects of the data with extensive expertise on specification and requirements. The processed data, or information, is delivered to users for benefits. This is the goal of digital transformation. For better effectiveness targeting the benefits, back-casting approaches are recommended for designing digital transformation. We will discuss details of the way in practice later in this chapter.

Because the digital transformation takes several stakeholders to a broad extent, the players of each component are usually in different positions. Therefore, communications and protocols are also important to coordinate the players for bridging the components. Recent development of ICT, specifically wireless communications such as Wi-Fi, has contributed to the progress of digital transformation by the role of transferring data and information between the players. The penetration of smartphones and Wi-Fi has accelerated digital transformation because use of the technologies does not need much infrastructure investment. Although smartphones are owned by individuals, those take a key role in realizing smart cities (Baltac 2019).

Major challenge of implementing digital transformation is redesigning the whole mechanism with harmonization between user capacity development and technology specification. Digital transformation is not just about putting paper documents online. It is about redesigning and shifting the various procedures we perform on a daily basis to the digital information infrastructure. A "perfect" technology could ignite a new innovation without any capacity development of users, but such technology

would cost a lot in R&D and production. Instead, the costs of R&D and production can be reduced by capacity development of users. Precise scopes also contribute to saving costs by reducing less prioritized requirements under the limited resources. Therefore, careful assessment of the current user capacity and potential user benefits is primarily needed for implementing digital transformation.

In conclusion, while the data and processes are the technology core of digital transformation, user capacity development is critical for implementations with harmonization of users and technology. We focus more on users in the following sections.

7.2 Why Digital Transformation for DRR?

The use of information is an urgent issue in DRR because of uncertainty. Sendai Framework stated promotion of ICT in disaster risk reduction, followed by numerous research and development, which provided near real-time information collection for decision-making and planning in disaster responses (Voigt et al. 2016). Until now, digitalization by departments has progressed, but when it comes to actually utilizing the information in the event of a disaster, various issues have emerged, such as the fact that it is unclear where and what information is accessible, and that it is impossible to combine the information due to incompatibility in data formats. In addition, in sectors that have not been sufficiently digitized (especially human service sectors such as health, medical care, and welfare), it has been difficult to collect detailed information, and, in many cases, it has been difficult to deliver services to those who need them in a timely manner.

The spread of digital information infrastructures through efforts to achieve Society 5.0 has created an environment in which information can be collected, analyzed, and used for decision-making in a timely manner. For example, SIP4D, an initiative project of the Japanese government, is one digital transformation approach that seeks to solve information challenges in DRR. SIP4D established a portal platform of disaster information collected from sources over ministries, authorities, and even academic and private sectors. The portal contributes to saving time of disaster management operations in information collection, which usually takes time due to cross-sectoral and bureaucratic processes.

As demonstrated in the SIP4D, digital format of information collection helped transferring and replicating them in the disaster operations. The portal covers information needed for planning logistics of humanitarian assistance, such as location of disaster-affected areas observed from earth observation satellites, location of disaster damages reported by public authorities, and locations of shelters. The information collection is advantageous in rapid operations during disasters, specifically the crucial 72 hours for delivering humanitarian assistance. SIP4D is a good practice of digital transformation for disaster management in public sector, but similar practices are also required for private sectors, especially public–private ventures and disaster reliefs. Although the digital transformation in DRR yielded higher performance in

upper stream emergency operations like disaster planning, it has potential to perform enhancement even in pre-disaster phases with citizens. Information in digital format is easy to refer to and archive. Besides, digital format is useful for calculating personalized evacuation plans. Just a single hazard map will not be sufficient for developing evacuation plans for various cases of disasters under uncertainties around the world. Digital formats will help citizens compose personalized evacuation plans and also support the evacuations in case of disasters.

As smartphones and wireless communications have penetrated among citizens, all the players in DRR including citizens, not only upper stream operators, benefit from better resilience through digital transformation. As the SDG states no one left behind, digital transformation in DRR shall cover everyone to multiply resilience against the unpredictable disasters around the world.

7.3 Technologies Supporting Digital Transformation

7.3.1 Utilization of Geographic Information Systems

As the basis for multi-organizational cooperation, reporting using an information sharing system such as GIS (geographic information system) has become effective in terms of centralization and visualization of changes over time. If the communication environment allows, reports with photos or videos of the situation (e.g., using photos on smartphones) will lead to a dramatic increase in the confirmation and understanding of the situation. Open data already available from the government, such as estimated flooding areas, evacuation shelters, AED locations, etc., can be used for preparation, and changes after a disaster can be plotted. It is also possible to create a classification chart that displays population attributes in different colors within a polygon (surface) to understand the movement of people and their needs, and to rewrite the chart to show rapid changes. In the past, the names and locations of evacuation centers other than the designated evacuation centers that were manually entered were not accurate and could not be tracked as the same evacuation center information, which was a fundamental problem that shook the information essential for epidemiology. Since a disaster is a change due to damage compared to the pre-disaster period, it is easier to quickly analyze the information after the disaster if a set of information is prepared in a form that can be changed from the pre-disaster information. For example, data and photos of past disasters can be used in desktop drills to pass on disaster experience, and if they are used in drills, they can be recorded to verify their effectiveness.

The availability of a wide variety of data owing to the development of ICT has enabled researchers using various methods to make new discoveries in an exploratory manner. Data scientists can help identify outliers, or deviant cases, and practitioners, who are front-line field workers, can investigate why such deviations occur. By

observing the real world, we can explore the causal mechanisms behind the correlations and patterns observed in statistical studies. In other words, we can understand whether what appears to be a correlation is a similar correlation or a possible causal relationship and show in detail how the hypothetical causal mechanism works. Alternatively, if the case studies lead to the identification of new variables and the elaboration of concepts, it is possible to verify whether the causal mechanisms assumed in the mathematical model are actually functioning. The variables and concepts obtained from the case study can be formulated to create a model. In addition to institutional policy and procedural reforms, changing social behavior requires coevolution with changes in the health environment related to people's beliefs, norms, and values that drive specific behaviors by routine health and safety monitoring and emergency reporting based on public health. Resources are often limited, and it is not possible to incorporate all reporting sources into monitoring tools. Governments will be required to coordinate rapid assessments to be interoperable with other data services for further collaboration with other sectors such as infrastructure, energy, transport, water, etc., and close coordination with local volunteers.

Data resources and GIS functions can be useful in providing information for decision support in primary health care and disaster response. However, each function cannot contribute to outcomes in isolation; they need to be connected and integrated. There is also a need to select among resources and functions. Within limited resources and budgets for primary health care and disaster response, resources and functions must be selected from a variety of options, with precise focus on the needs of the end user.

7.3.2 Data Management and Sharing

Since a considerable amount of data is stored in GIS, it needs to be made accessible to a variety of users. In the past, collecting data and sharing the results with various groups of organizations was a difficult task because of the guidelines and rules involved. However, recent advances in technology have allowed users to access data from remote servers via the Internet. Cloud computing for GIS-based systems has been recognized as an excellent tool to improve traditional GIS applications and provide comprehensive services to users around the world. As a result, various GIS applications are also being converted to cloud computing. Also, some GIS vendors have taken a technological step toward managing data in the cloud to provide specific purpose services to users. GIS on cloud computing makes data collection in the field more convenient with mobile data collection that can easily digitize paper workflows. In short, GIS on cloud computing provides proper on-demand network access to share, provide, and manage resources such as servers, storage, applications, networks, and services.

In the scientific field, we also propose a framework to improve the flexibility and reliability of exchanging different types of data (private and public data), applied in different fields, to extend their valuable benefits (Cao and Wachowicz 2019; Helmi

et al. 2018). Another approach in interdisciplinary research for data management and analysis is Open geospatial infrastructure (Jeppesen et al. 2018). For example, GeoNode is a web-based application and platform for developing GIS and deploying spatial data infrastructure applied to disaster management. It is a web-based application and platform for deploying spatial data infrastructure applied to disaster management (Damalas et al. 2018).

Some more basic examples of software that help manage and share data are common cloud applications such as Google Drive, OneDrive, and Dropbox. These are traditional applications as the capacity to store files on a server, synchronize data across devices, and share files. There are also platforms that propose the ability to easily manage data storage and share information across organizations. Examples are Kobo Toolbox, ArcGIS, and QGIS. Ushahidi (https://www.ushahidi.com) is another example. Ushahidi is an open-source software application that was initiated and developed to map reports of violence in Kenya after the 2008 post-election riots. The application is based on the concept of crowdsourcing and provides an initial model as activist mapping and hence is being used as a platform for crisis response like the 2015 Nepal earthquake. For example, in the 2015 Nepal earthquake, it was used as a platform for crisis response in the ongoing relief efforts being undertaken by various government, non-government, and volunteer groups (Waugaman 2015). Human rights reporting, such as that deployed to track, count, and honor the victims of the Syrian conflict (Meier 2011) or election monitoring, such as that of the 2012 US elections (Manning 2016).

7.4 Do It Yourself! Participatory Digital Transformation

In the context of community-based disaster management, we used a participatory geographic information system (PGIS) approach to understanding the spatial dimensions of flood concerns of female disaster management community members in Kochi Prefecture, with the aim of enhancing livelihood disaster management at the local level. In this case, we propose a mixed-methods approach that applies participatory sketch mapping as a way to gather local knowledge about community perceptions of flooding in a data-scarce context (Fig. 7.1). This local knowledge, combined with a quantitative geo-equation hotspot analysis of the basic infrastructure features of the village, provides insights into community perceptions of and responses to flood risk. The importance of this study lies in the application of the PGIS method to create two different primary data sets: one (essentially more qualitative) data generated from sketch maps by community members, which was used to understand how people spatially conceptualize hydro-meteorological hazards in their communities, and the other (essentially more qualitative) data generated from a series of sketch maps by community members, which was used to understand how people spatially conceptualize hydro-meteorological hazards in their communities. It was used to understand how people spatially conceptualize hydro-meteorological hazards in their communities. Our study provides an example of a sketch mapping approach that facilitates

Fig. 7.1 Mapping disaster risk from the perspective of women in the community

multi-level management of community-level flood risk in a data-deficient environment and demonstrates the multiple benefits of applying participatory GIS methods. This is a dynamic regarding the lack of data on gender, livelihood, health, etc. and contributes to the participatory GIS literacy.

7.4.1 Service Design for PGIS

Most service design work is done in teams, rather than independently. Therefore, brainstorming with team members is necessary to define the problem. Brainstorming is a process of free thinking, but by using a frame to guide the thinking, you can encourage purposeful thinking and consolidate the team's ideas effectively in a short time. It helps to consolidate the team's ideas effectively in a short time.

The solution to the problem of primary health care in the community is to bring together not only the people facing the problem in the field, but also the people using and providing the technology, to form a team, and to bring together the people providing and using the technology, to form a team, to form a technology solution to the problem. The method proposed by the author is to have the team write down problems of interest and ideas for solutions on sticky notes, and then organize them into a problem/issue and technology matrix. The idea is to organize them into a matrix of problems/issues and technologies. This helps to visualize the team members' awareness of the problem, their concerns, and their potential contribution, and to identify what the team can do immediately. This approach can also be used in time-limited

training programs and, more recently, online virtual whiteboards, which allow international interdisciplinary teams to collaborate regardless of their diverse locations and positions.

In the process of identifying what the key stakeholders want, one of the following cases emerges for the issue under consideration:

Case 1: Stakeholders lack the information they need to make decisions. Cases where stakeholders can take the next step by providing information such as "I want to know about _____."

Case 2: Conflict or contradiction among stakeholders. When "I want to _____" causes conflict or contradiction among stakeholders. Government "I want to accept evacuees" residents. "I don't want to accept evacuees because it will make me feel unsafe."

With customer value chain analysis, which schematizes the relationship between stakeholders in terms of benefits and rewards, this allows us to summarize the conflicts and contradictions. For analysis, the framework of Donahue and Joyce (2001) is useful, which analyzes players in terms of their functional competencies and motivational incentives. They use this framework to analyze the relationship between national and local governments and provide recommendations on information control in emergency disaster response. Customer journey mapping is a method to illustrate how users feel and respond to a service by assuming the characteristics of service users, and is effective in analyzing aspects from the perspective of individual users. In the field of primary health care, some data resources are difficult to use for research and development or operation from the perspective of privacy protection. Here, data resources need to be selected by identifying the minimum requirements for data to contribute to problem-solving.

7.4.2 Data Accuracy

Since spatio-temporal data often play an important role in primary health care, the requirements for spatial and temporal accuracy need to be analyzed. While measurement accuracy is important in laboratory experiments, it is considerably more important in primary health care to capture variation and variability in location, time, and environment.

Spatial accuracy is the spatial spacing or density at which data is observed or acquired, and is sometimes referred to as resolution or scale. For example, satellite imagery displayed in Google Earth has a resolution of 0.3 m/pixel and can identify land areas larger than 0.3 m. However, if the images displayed in Google Earth are to be used for purposes other than viewing in Google Earth, they must be purchased from Maxtor, the data provider, at a cost of about US$20/km^2. This trade-off also applies to positioning technologies such as GPS. The positioning accuracy of a typical

smartphone is about 10 to 100 m, but a device that corrects for centimeter accuracy can cost as much as US$10,000.

High-precision data may seem useful and applicable to all applications, but the trade-off between accuracy and cost makes it less versatile. In addition, high-precision data can sometimes violate privacy, making it rather difficult to use. To keep the cost down to a practical scale, an important issue is to choose the right spatial resolution for the data. In addition, since there are many different data sources for spatial data, it is necessary to consult with experts.

Temporal accuracy refers to the interval at which data is observed and acquired, sometimes referred to as frequency. Latency, which is the time it takes for data to reach the user, is another specification of temporal accuracy. As with spatial accuracy, there is a trade-off between cost and latency, which depends not only on the cost but also on the performance of the communication facility. Of course, data transmission cannot exceed the maximum speed of the communication facility. Also, in remote areas, frequency may be limited due to power outages.

Sacrificing frequency can greatly reduce the cost or even improve the accuracy of communication. For example, a cell phone communicates through a call connection, but is always connected during a call. In situations where the communication infrastructure is not well developed, voice quality may be poor, and information may not be conveyed accurately. However, by sending text (SMS) instead, the information transmission becomes more accurate. This improves the performance of information transfer at the expense of real-time performance and reduces costs by reducing connection time.

As with spatial accuracy, specifying the appropriate temporal accuracy can be done in consultation with experts, reducing costs, and even improving the quality of service.

7.4.3 Prototyping Process: Rapid Prototyping for Disasters

The prototyping method is useful for emergency disaster response where services must be released quickly, even if the functionality is not perfectly implemented. Here, technology providers and users work together to rapidly implement and validate the service under a concise prioritization. It is also important to adopt frameworks that allow for easy functional extensions. Mabi-Care in Japan is an excellent example of this procedure being effectively implemented.

In order to carry out such prototyping in times of disaster, it is necessary to cultivate a foundation for team building during normal times. Civic tech is an initiative that encourages dialogue between users (citizens) and developers and promotes team building even during emergencies.

In typing, the emphasis is placed on developing within a limited time and budget. This constraint and condition is important for rapid release of customized applications, especially in disaster management. This will allow us to refine features and

performance by demonstrating them with readily available technology and identifying useful, useless, extra, and missing features and performance. Sometimes new ideas come to us while we are researching the latest technology. In that case, you can always go back to the previous section. By repeatedly checking problems, issues, and technical specifications, the service development will be refined.

Once you have determined the specifications of the data you need, search for technologies that meet those specifications. When searching for the first time, you may not be able to immediately determine which of the many search results to choose. Not surprisingly, cost and price are the most important factors. In such cases, it is possible to sample only the minimum amount of data needed for functional verification or to prepare dummy data. No matter how sharp the problem or specification, the technology required for data acquisition may be very expensive in terms of budget. Technologies with large cost estimates are often over-specified. In such cases, it is necessary to re-evaluate the problem and the data specifications.

Expert advice is also important in finding the right technology. This will determine how the prototyping will be accomplished within a limited budget and time. It is assumed that the data will be supplied automatically, but the only way to start is to create it manually. This is a time-consuming process, but it is an important process that allows us to notice design oversights by describing the data while envisioning scenarios.

Once the development of the prototype is complete, verification and evaluation through trial runs are conducted. Here, it is important not only to make sure that the system works stably, but also to get feedback from users by touching the system. The key points to get feedback are (1) Was the information provided at the right time and in the right form? (2) If the right information was not provided, what was the problem? For example, the following problems are found in many cases:

1. The presentation of the data is too technical for the users to understand.
2. Data at critical times is missing because of insufficient frequency.
3. Insufficient latency to serve users when they need it.
4. Inability to make accurate decisions due to inappropriate spatial accuracy.

After analyzing the data from these perspectives, we will review the data specifications. If it is found that the current technology is not capable of handling the problem, the problem should be reviewed again.

7.5 Challenges in Digital Transformation for DRR

Regardless if smartphones and Internet connections are available, the capacity to use those is another issue. For example, the SIP4D currently provides an information portal with higher usability developed through practice of digital transformation. However, the information shown in the interface is still too much and complex for citizens to handle and interpret. We may have two measures to address this issue.

The first is to increase the capacity of citizens to utilize the information. This can be achieved by providing capacity development programs. Because citizens' backgrounds and experiences are in a wide range of varieties, programs need classes by capacity to support them. While some citizens can quickly get used to much and complex information, the others will take a long time to equip themselves with knowledge and skills. For feasible efficiency, capacity development programs have to be designed with long-term programs along with development of systems for digital transformation; otherwise, even when a new system is established, only a few users can utilize the new system, so little outcomes for the investment.

The second way is to develop user-friendly interfaces so that even beginners with little skills and knowledge can reach the benefits of digital transformation. The interface development has to be aligned with users skills and knowledge for specifying functional requirements because even a newly developed user interface may require a certain level of skills and knowledge. Therefore, this approach should be along with capacity development programs.

Citizens' participation is a key procedure in this development process. Once citizens are involved in capacity development, we can precisely specify requirements of user interface development from citizens through capacity development programs, and then, we can have citizens' feedback to the developed interface. The development cycle between citizens and developers promotes digital transformation in DRR, aiming for utilization of disaster information by citizens.

In summary, capacity development is a primary requirement of digital transformation for citizens to access disaster information. Also, user-friendly interfaces will help citizens to utilize the information.

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Chapter 8
XR and Implications to DRR: Challenges and Prospects

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Abstract This chapter identifies issues in disaster education and explores necessary research and education based on lessons learned from the catastrophe and a compilation of existing efforts in Japan. Furthermore, on the other hand, it outlines the technological development of XR and introduces good practices in XR and disaster management. It was found that even without programming or 3D experience, people with local knowledge can recognize the fear and importance of protecting life and health during disasters in their daily lives by being able to experience an immersive spatial environment after checking damage information. In the future, it is necessary to consider a combined platform for education, training, and community activities, taking into account the characteristics of the disaster situation, the type of data, analysis methods and delivery.

Keywords Virtual reality · Augmented reality · Extended reality · Disaster literacy · Metaverse

8.1 Introduction

The word "Bosai(防災 Disaster Prevention)" has been a keyword when discussing measures to deal with the many natural disasters expected in Japan. In addition to "disaster prevention," other technical terms such as "disaster drills," and "community disaster risk management" have been used for hundreds of years. After several major disasters in recent decades, it has become clear that large and complex disasters cause sudden and unpredictable damage to local governments, fire departments, and other agencies in charge of quick response. Maintaining "human security" in all disaster

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cycles has been strongly recognized, as large-scale disasters affect a much wider area and are more complex to manage. The term "Gensai" (disaster risk reduction or mitigation in Japanese) has come into everyday use due to the limitations of disaster prevention activities of local governments and public services (e.g., lack of human resources for firefighters in times of disaster). Citizens were required to engage in voluntary "disaster prevention actions". Furthermore, the government's Reconstruction Design Council, established immediately after the Great East Japan Earthquake in 2011, declared that the keyword for preparedness in Japan has shifted from "disaster prevention" to "disaster mitigation." The idea of maximizing the reduction of damage from disasters and providing relief to all victims has come to be accepted as a general theory of disaster (Reconstruction Design Council for the Great East Japan Earthquake 2011).

Within Society 5.0, local risk communication data can be used by society to proactively reduce risk and improve resilience. In this context, XR, including VR and AR, can display three-dimensional images that cannot be seen from real objects and provide feedback on the sensation of touching things. This paper introduces XR, which has the potential to bring about significant changes in literacy and communication for individual and community disaster mitigation. First, we review disaster education to date. Then, the development of disaster education using XR technology focusing on "perception and action," which are necessary for risk reduction but have been difficult to acquire, is described.

8.2 Disaster Literacy and Current Education on Disaster Preparedness

"Disastser Literacy" is "the ability to have a good understanding of the mechanisms of natural disasters, the local natural environment, past disasters, and the mechanisms of disaster prevention systems, to have an awareness of the risks in the event of a catastrophe, and to act quickly". The term "disaster literacy" came into use only in the last 20 years, though a similar concept has existed since 1995. Disaster Management Lliteracy" is "the ability to have a good understanding of the mechanisms of natural disasters, the local natural environment, past disasters, and the mechanisms of disaster prevention systems, to have an awareness of the risks in the event of a catastrophe, and to act quickly (Kimura 2017). The term "Health Literacy" (WHO 1998) is already often used to describe the cognitive and social skills that determine an individual's willingness and ability to access, understand, and use information in ways that promote and maintain health. Many important factors have also been added, including cognitive skills, social skills, ability to access information, insight, desire, and confidence (Nutbeam 1998; Nakayama 2008).

A conceptual analysis of "Literacy for Disaster Risk Reduction" was conducted by reviewing Japanese websites, newspapers, government reports, and other materials

for the past 20 years, within a specific time and across disciplines, and those used in emerging and developing research fields (Kanbara 2016).

The Central Disaster Management Council stated, "Public support by the government is essential to insure against natural disasters (Cabinet Office 2006a)". In addition, individual self-help awareness and mutual help are also essential when the policy was formulated to "develop a national movement in which individuals, households, local governments, and businesses make step-by-step investments" (Cabinet Office 2006b). Local governments worldwide have also begun to work on developing this national movement. The Study Group on the Implementation of Volcanic Disaster Prevention Measures has identified "improving disaster literacy" as an effective method for improving local disaster-preparedness against low-frequency disasters like volcanic eruptions (Cabinet Office 2012b). In addition, citizens need to have the "intelligence" to protect themselves for voluntary self-help and cooperation in times of heavy rainfall, for example, how to obtain information on disasters and disaster prevention, how to evacuate appropriately, and the actual situation in the community (Cabinet Office 2010b).

During this time, several educational works on disaster literacy have been published, including the case of "movement-based learning". In this school's approach, "zest for living" equals "acquiring the 'information,' 'skills,' and 'motivation' to take charge of one's own life" (Suzuki 2002).

Educational methods to enhance these literacies include learning by pictures, learning judgment and application skills in workshops, and confirming knowledge and preparedness for disasters through experience. Games and festivals can also provide knowledge and habits useful for disaster education. Knowing the risks in a disaster and solving problems will enhance the individual's survival ability. An increasing number of comprehensive educational programs integrate disaster prevention education and life education (Hyogo Prefectural Board of Education 2006; Kanoe et al. 2006)

Three concept components were extracted from the literature review, and the concept was appeared, "Knowledge (types of natural disasters and their lessons)" "Awareness (respect for life)", and "Techniques (first aid, et al.-defense, survival skills etc)". These components include items related to people, the environment, behaviors, and information necessary for care. If the actions are taken smoothly, disaster risks can be reduced.

First, proper disaster awareness means always being prepared. Citizens' preparedness is always linked to their attitudes toward disasters. To prepare for unexpected events, one must understand the "fear of disaster." Another is to think about the "value of everyday life" and "life." These thoughts create confidence and insight, and people know their roles in the disaster. For example, after the Great East Japan Earthquake, they learned that "citizens should not wait to escape, each of us should protect themselves and everyone else" (Kanai and Katada 2012).

The second essential element is information about the technology used to exploit the available resources. For example, suppose they learn "mechanisms" such as "types of disasters" and "lessons learned in the past" from photos and video records.

In that case, hazard maps and simulations to show "dangerous places in the neighborhood and estimated damage" can be used. Then, when a disaster strikes, the public can understand "evacuation sites" and "evacuation methods" and get the information needed to protect themselves.

After residents have obtained the necessary information, technique becomes essential. They need to "gather information" from others, for example, TVs, computers, and cell phones. Thus, they can take "evacuation action" to a safe place. It also means taking "risk-avoidance actions" during the evacuation, such as avoiding areas with collapsed infrastructure or dangerous places where electrocution is possible. Health-related skills include "first aid," such as treating wounds and performing CPR.

In other words, by knowing the information, residents can accurately assess the situation and take action to minimize the damage. This procedure leads to disaster risk reduction and allows people to take "appropriate actions to ensure safety" and "appropriate actions regarding health."

The Great East Japan Earthquake demonstrated the disaster literacy of elementary and junior high school students who experienced disaster prevention. It is crucial to have a methodology to enhance literacy. It became clear that improving the literacy method is essential (Kimura 2012). Changing perceptions and experiential interventions are necessary for learning about disaster prevention. These examples show that citizens' continuous awareness and daily preparedness can lead to an effective response in times of disaster, indicating a shift from disaster prevention to disaster mitigation.

It is important to note that risks vary from person to person, organization to organization, and region to region. In other words, even if the government uses raw scientific data to estimate disaster prevention universally, disaster prevention will change depending on the social context (Murosaki 2011). For example, even if the government predicts that an earthquake will occur within 30 years, the response will vary depending on the citizens' age, occupation, and cultural characteristics. Moreover, not all risk reduction actions are based on raw scientific data since they involve people and organizations. Therefore, it should be kept in mind that disaster reduction actions are influenced by the characteristics of society (Seki 2010).

It seems not easy for younger people, such as elementary and junior high school students. These literacy should be acquired naturally in society. For swift qualified actions in a disaster, it is essential to ensure people's safety and continue with safe actions. It is also necessary to assume disaster risks, consider reducing them, and act daily.

It is believed that people are vulnerable to disaster risk even before the disaster strikes due to factors that differ from other life issues. The review of disaster prevention and mitigation education and awareness-raising has shown that disaster risk reduction requires a concerted effort by people. When people in the community have awareness and knowledge of disaster mitigation, they can make appropriate decisions and take actions to minimize damage (Kanbara 2017).

8.3 Disaster Literacy on Society 5.0

At the same time, in Society 4.0, or the information age, social information sites and other web resources that rely on the collective knowledge of human beings, have brought together the opinions of a group of individuals, rather than the opinions of a single expert. The process and the wisdom of crowds have become mainstream. A common feature of many sites and services is that even non-technical users can quickly disperse information by combining the knowledge and information held by various disseminating entities. The information and functions provided by websites such as wikis, social networking services (SNS), blogs, and social bookmarks serve as a kind of foundation.

In terms of disaster-preparedness in Japan, DRR 4.0 emphasizes building a society that can respond to increasingly severe disasters autonomously and optimally through self-help, mutual-help, and public-help efforts (Cabinet office 2016). In Japan, with an eye on Society 5.0, the Strategic Innovation Program (SIP) has been defined as "Society 5.0 in times of disaster." The second phase of SIP aims to expand the disaster information sharing of the first phase and provide information to support the national government's and municipalities' decision-making. One of the core technologies is the digital twin, which aims to predict the transition of disasters in society, including disasters, disaster response organizations, disaster survivors, and the development of a disaster prevention chatbot (Secretariat for Science, Technology and Innovation, Cabinet Office 2022).

Now, technological innovation is driving in more natural ways for us to connect, from chatbots for business to social VR. AR, an extension of VR, blurs the line between real and virtual, keeping us interfacing with both the digital and physical worlds simultaneously. XR is progressing faster than ever before and has the potential to merge with a multitude of innovative technologies. It will promote transparency, break down data silos, and enhance shared innovation.

8.4 XR and the Potential for Disaster Management Application

This section includes XR for disaster management in Japan and its future development. XR is a generic term for technologies that allow us to perceive things that are not in reality by fusing the real and virtual worlds. Therefore, technologies such as virtual reality (VR), augmented reality (AR), and mixed reality (MR) are all included in XR. Technologies that combine VR and AR are emerging, making it difficult to draw boundaries.

VR stands for "Virtual Reality," a technology that allows users to experience the virtual world as if it were real by wearing a unique head-mounted display to share the all-around images created by CG or 360° cameras. It comes to be used in VR

meetings and training where avatars are displayed in the virtual world, VR campuses, and offices that use similar technology.

AR stands for "Augmented Reality," a technology that allows users to experience the virtual world superimposed on the real world. When looking at the natural world through a smartphone or head-mounted display, it "augments" the real world by displaying data and images that are virtual entities. There are images of the natural world and information from the virtual world, allowing the experience of what it is like to be at a disaster scene while at home.

MR stands for "Mixed Reality," a technology that fuses the real world with the virtual world. While AR "augments" reality by displaying information from the virtual world in the real world, MR aims to "combine" the real and virtual worlds more closely. In other words, MR is in "fieldwork," technologies such as superimposing 3D images of disaster prediction on the actual work site or recording the progress of a worksite with a 3D camera and checking it remotely. These technologies have been spreading rapidly in recent years.

The first study in which Virtual Reality was used in disaster management was an experiment to alleviate post-disaster PTSD in U.S. Army soldiers (Difede et al. 2007). Virtual reality exposure therapy for the treatment of post-traumatic stress disorder was conducted following September 11, 2001 (Journal of clinical psychiatry, 68(11), 1639). Ukawa et al. (2014) developed a smartphone tsunami AR (augmented reality) application for disaster prevention education. The height of the tsunami that arrived at the Great East Japan Earthquake site is displayed as icons and numbers on the real-time video, but CG represents the tsunami. The University of Tokyo's Institute of Industrial Science, Takaaki Kato Laboratory, and Cad Center Corporation (2014) developed an application for visualizing disaster prevention information with a smartphone (2014). Based on the GPS location information of the device, a CG image of the water surface at the assumed height of flooding is superimposed on the real-time image of the smartphone's camera, allowing the user to grasp the danger of the current location in three dimensions. Itamiya and Yoshimura (2016) developed an AR application that uses a smartphone and paper goggles to provide an immersive experience by superimposing floodwaters and smoke on the entire landscape in a three-dimensional CG display.

Disaster Scope is a mixed reality application that uses a smartphone and paper goggles to display CG images of flooding, smoke from fires, and other disaster situations overlaid on natural scenery for an immersive experience. A smartphone with a sensor can precisely detect the height position from the ground and recognize the surrounding objects. It is possible to realize more realistically the flooding of a low water level of 1 m or less and the filling of a room with smoke. In evacuation drills and disaster prevention events at elementary and junior high schools, it has been shown that the system can provide a real sense of crisis, suggesting that it helps raise crisis awareness.

8.5 Feasibility Study on School Education

The version using the 3D depth sensor is not very versatile because it only works with Zenfone AR. In recent years, ARKit and ARCore have been introduced to realize spatial recognition by software using only camera images without sensors. It is expected that a new type of disaster prevention education that links this application with existing educational programs will spread nationwide.

8.5.1 AR Flooding Experience App Disaster Scope® Floods

This application was developed using Unity, ARKit, and ARFoundation. The app enables realistic representations of flooding related to real space by using only smartphones. The built-in camera and LiDAR scanner of the iPhone 12Pro/iPad Pro 2020, a commonly available smartphone, perform spatial recognition in real-time. The height of the smartphone from the ground can also be acquired. The shape can be automatically recognized without a 3D depth sensor, enabling occlusion representations of people and water surfaces. For objects, the ARFundation function is used to detect the shape of surrounding things and perform occlusion representation. There is no time lag between the shape recognition of the person and the space. A realistic representation of the water surface at an arbitrary depth set by the user is now possible if the water surface were flooding around the person or object. It is also possible to control the water surface's color and velocity, the presence or absence of drifting objects, and the representation of rainfall and storms. The water surface height can be set in 10 cm increments by the buttons on the screen. The system can also be connected to the WebAPI of "Inundation Navi," an online hazard map provided by Japan's Ministry of Land, Infrastructure, Transport and Tourism, to automatically acquire the estimated maximum water level at the current location. Namely, when the application user crouches down, the display will appear as if the user has entered the water.

8.5.2 AR Smoke Experience App Disaster Scope® Fire&Smoke

A Head-Mounted Display, Lenovo Mirage Solo, is essentially a VR goggle. It uses two cameras on the front of the device to provide a video see-through stereoscopic view of the surrounding real space. Therefore, it can also be used as an AR device and developed an AR smoke experience application using Unity and Google VR SDK for Unity. When the app is launched, 3D-CG smoke appears to fill the actual space in front of the user. Since smoke is lighter than air, it floats from the ceiling when a fire occurs indoors. This application allows users to simulate an about 100-m^2 room after

about 3 to 5 min fire. Since the bottom of the smoke is approximately 60 cm from the floor, they can get out through under the bottom of the smoke and gain visibility by crouching down or taking other low postures. They can feel the existence of the "neutral zone," which is the boundary between the bottom of the smoke and the air. This simulation allows the user to realize the necessity of evacuating with a low position to avoid inhaling harmful smoke in the event of a fire and how smoke can obstruct one's view.

8.5.3 The Utilization of the System

The system was used in an evacuation drill for 334 students at Mitaka Municipal Seventh Elementary School in Tokyo in February 2020 and an evacuation drill for all 120 fifth-grade students at Takayama Municipal Elementary School in the same month. The AR flooding experience is shown in Fig. 8.1 and the smoke experience in Fig. 8.2. In addition, a total of 100 other elementary, junior high, and high schools also used this application for disaster education.

8.5.4 Evaluation

A questionnaire survey was conducted on the children who experienced the program. Figure 8.3 shows a graph of the responses to the question, did the experience of flooding make you feel scared?, Fig. 8.4 shows did the experience of smoke make you feel scared?

8.5.5 Considerations and Future Issues

We also asked "Did the two experiences (flooding and smoke) make you think about taking disaster-preparedness actions?". The questionnaire survey results suggest that this system helps raise awareness among elementary school students of the crisis and daily countermeasures. Analysis by grade shows that 65% of the 1st–3rd graders "strongly agree" with the system. In comparison, 73% of the 4th–6th graders "strongly agree" with the design, indicating that the higher the grade gets, the higher the evaluation of the system tends to be. The need for pre- and post-learning in the first grade is evident. It is necessary to closely link the AR experience with the disaster-preparedness lessons in the classroom to improve understanding at all grade levels.

Fig. 8.1 The AR flooding experience at elementary school

Fig. 8.2 Smoke experience at elementary school

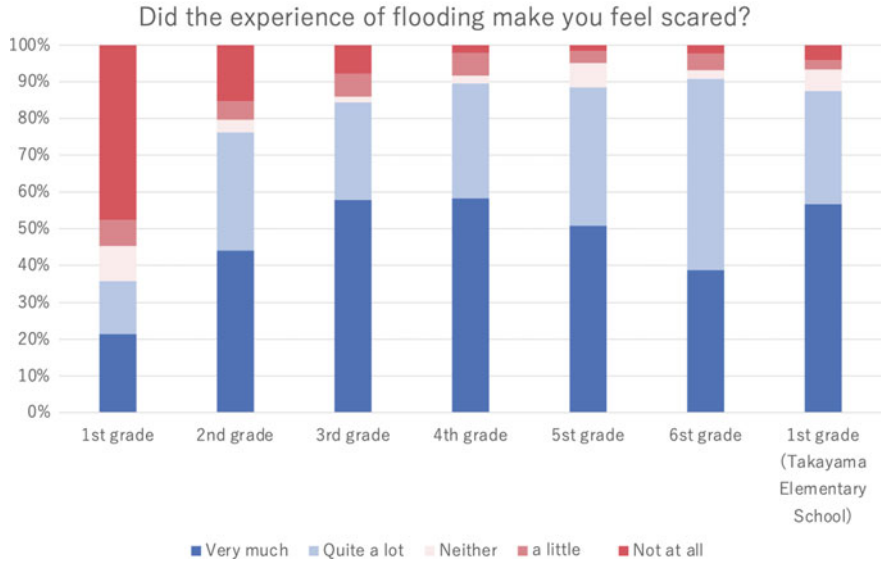

Fig. 8.3 The responses to the question, "Did the experience of flooding make you feel scared?"

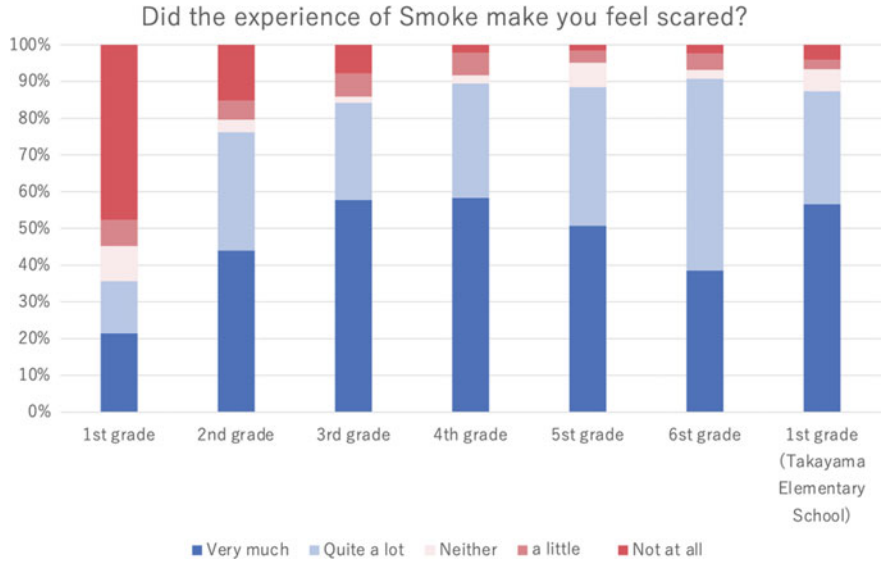

Fig. 8.4 The responses to the question, "Did the experience of smoke make you feel scared?"

8.6 Implementation and Promotion on Community by Local Government

8.6.1 Yokohama City: Yokohama Evacuation Navigation System

In Yokohama City, the "Yokohama Evacuation Navigation System" was developed to support individual evacuation behavior from "now" (regular times) to "when disaster strikes" (emergency times) in an integrated manner. First, to raise awareness, provide technical support for easy access to Disaster Scope from the app's home screen and incorporate a mechanism that allows users to simulate flooding through AR. Secondly, to support evacuation behavior, in the event of a disaster, the app provides push notifications of evacuation information linked to "My Timeline," a chronological evacuation action plan. It allows users to check evacuation sites and routes already established. To create "My Timeline," a "My Timeline Creation Sheet" is distributed to all households and inundation hazard maps. Training is conducted in areas at risk of inundation and landslide disasters. In this context, industry, government, and academia have agreed, with the author's university providing the inundation simulation (AR) technology, a startup company building the system, and the local government providing the know-how for the actual activities (Fig. 8.5).

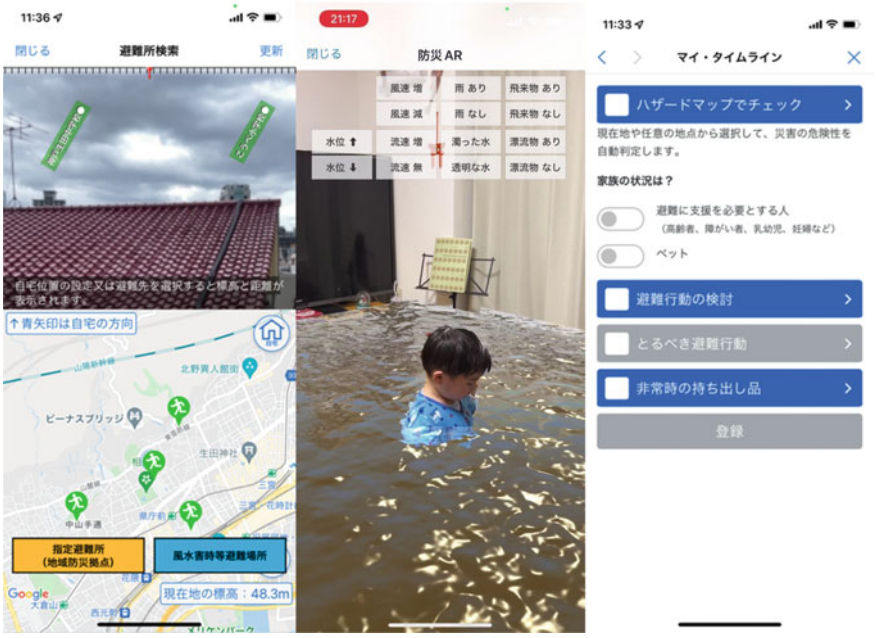

Fig. 8.5 Yokohama Evacuation Navigation System with AR (Yokohama city 2022)

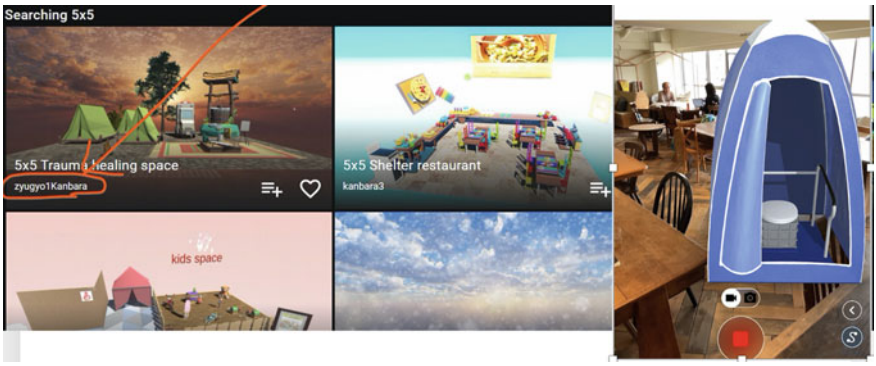

Fig. 8.6 Visualization of health resilience using STYLY

8.6.2 Kobe City Urban Innovation Challenge

In Kobe City, there are several facilities for disaster education based on the experience of the Great Hanshin-Awaji Earthquake in 1995. A variety of disaster education programs have been developed in an advanced manner. Meanwhile, the city learned the importance of life anew after the earthquake. In order to rebuild the economy after the significant damage, the "Kobe Medical Industry Development Project" was initiated as a reconstruction project after the earthquake. In recent years, the city has recommended an open innovation platform that matches the challenges of local governments with startups and private companies. Municipal officials and companies collaborate to create entirely new businesses from their insights and discoveries. In one such project, industry, government, and academia have formed one team to develop a citizen service that focuses on the coexistence of fun and improved risk awareness, rather than mere disaster prevention knowledge, while verifying the effects of realistic experiences and XR. The Disaster Scope was loaded on STYLY and used in conjunction with the realistic experience equipment at the Citizen's Disaster Prevention Center and other facilities to allow the general public who are not interested in disaster prevention to experience disasters (Fig. 8.6).

8.6.3 Kochi: Gaining the Literacy for Emergency and Resilience

Kochi Prefecture has a declining birthrate and an aging population. Also, securing medical personnel is a critical issue. In addition, the prefecture is prone to extensive natural disasters such as a Nankai Trough earthquake, tsunami, torrential rain, and typhoons. Local human resources are required to maximize their abilities, especially in remote areas, where dispatching personnel in a disaster is complex, and many

Fig. 8.7 On-the-job training for an emergency response using VR

people cannot gather. In Muroto City, located in the southernmost part of Japan, the use of VR in the region was surveyed. The challenge was to secure the necessary funds. Using a "VR injection simulator" developed by a startup company, iMA CREATE, disaster nurses conducted training in cooperation with universities. In addition, the Muroto UNESCO World Geopark is attempting to connect 360° views of the landscape with people's daily lives with a VR application (Fig. 8.7).

8.6.4 Metaverse Disaster Training

It is essential to take advantage of VR and AR and select the suitable production method for the right person according to the educational content to be implemented and the desired effect. These diverse experiments show that VR is appropriate for earthquakes response education and AR is suitable for flooding and fire smoke. In particular, a handy system is imperative to incorporate into evacuation drills at schools and workplaces. Since everyone must experience the system, the experience time per session should be within 2 to 3 min, multiple pieces of equipment should be prepared, and routine operation is crucial. However, it is not realistic because it requires 3D-CG modeling of the location to be experienced, and customization costs several million yen per experience. However, superimposing the disaster situation makes the education more "personal" and palpable. Since 3D-CG modeling is not required for each location, it can be realized at a low cost. With location information,

Table 8.1 Comparison of AR and VR in different situations

	Flooding	Fire and smoke	Earthquake
AR	Extremely well	Extremely well	Not at all
VR	Moderately well	Moderately well	Extremely well

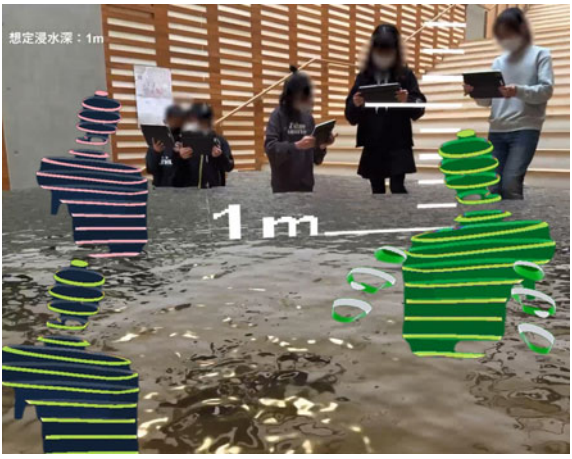

Fig. 8.8 Image of metaverse disaster drill

numerical information from hazard maps can be visualized and experienced in AR (Table 8.1).

Until recently, VR/AR has been a one-person experience, but with the realization of a metaverse mechanism that allows multiple people to share a single virtual space, evacuation drills and disaster education using VR/AR are approaching the next step. Whereas disaster drills have been held at specific locations at specific times, with the metaverse, people can participate from their homes, freeing them from location constraints. High-speed networks, including 5G, need to be developed. Additionally, a common metaverse infrastructure, including STYLY, needs to be widely utilized (Fig. 8.8). It is also needed to develop an easily accessible infrastructure that is economically inexpensive and does not require operational training.

8.7 Way to Forward

Due to the frequent occurrence of disasters in Japan, the "Disaster Countermeasures Basic Act" is enacted. Under this law, the head of each municipality shall develop and maximize the use of voluntary disaster prevention organizations, firefighting organizations, flood prevention organizations, and other public organizations for disaster prevention within that municipality. They shall also ensure that all municipality facilities are fully functional to promote voluntary disaster prevention actions by citizens. The law states that citizens of local governments shall endeavor to contribute

to disaster reduction by participating in disaster drills and other voluntary disaster reduction activities, teaching lessons learned from past disasters, and other efforts. Also, the National Protection Law states that the citizens shall endeavor to provide necessary cooperation when requested to implement measures for the protection of the citizens under the provisions of this Act. Further states, The national government and local governments shall provide the necessary support for voluntary actions by volunteers and independent disaster prevention organizations that contribute to emergency response and care (E-Gov 2012).

Disasters can be caused by natural phenomena like climate or artificial factors and damage society. However, while the individuals' ability to help themselves is emphasized, they are helpless without resources. In addition, some people have difficulty obtaining information or cannot act alone. Therefore, the barriers between organizations must be removed by determining cooperation and countermeasures and working with individuals. During the response and recovery phase, nutrition from limited sources and proper hygiene in shelters and temporary housing will help maintain health and prevent illness. Potential problems in the community can be significantly amplified during the response and recovery phase. Large-scale artificial disasters are also a global issue. In addition, more damage by natural disasters has been caused by climate change and population growth in recent years. Human-centered disaster reduction requires a more detailed study of the immediate responsibilities of citizen participation in disaster management based on human security.

Continuous disaster-preparedness must be developed for community resilience. First, people need to be reminded of the risks that can be expected based on expert findings and scientific data and know-how to avoid those risks. Citizens should recognize the disasters they are susceptible to, determine what actions to take, and be prepared. In addition, the finding from future disaster management research, including other cognitive behavior through XR, can provide a wealth of education, practice, and health policy relevant to humans pre-, during, and post-disaster. XR should be required in many aspects of the post-disaster period. XR can play a significant role in providing those who keep moving in the region with essential insights into the imminent risks to the community.

Disaster information and risk communication contain many lessons from the existing literature on emergencies and disasters. However, many studies may have overlooked the wisdom and experience of local life in disaster relief and prevention activities. Therefore, it is necessary to integrate the information perceived by those who have been in and out of the affected areas to contribute to continuous risk perception, including medium- and long-term effects. Other parties often determined disaster prevention plans and response measures in the past, and residents' risk perceptions were not sufficiently integrated. It may lead to inadequate understanding of risks and resources in the community during disasters, making it unfeasible to avoid risks.

To remedy this situation, XR needs to take on a life-stream-based behavioral model of individuals that adheres to a vertical structure rather than recognizing that multiple stakeholders will simultaneously provide relief. Anyone with an idea has access to the data and technology needed to build it, and everyone has the potential

to benefit from its development. Innovation is an isolated situation without an open-source, distributed, partially owned architecture to support these systems. Individual companies with their systems have no incentive to share data, technology, or ideas. In this context, each risk-aware citizen describing and expressing their perceptions contributes to an entirely new understanding of disaster risk.

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Chapter 9
Open Governance and Disaster Risk Reduction

Yishuang Zhang, Jiang Yongxi, Yang Yueqi, Vibhas Sukhwani, and Rajib Shaw

Abstract Against the growing frequency and intensity of disasters worldwide, and the pressing planetary and socio-economic challenges, the close alignment of scientific efforts with the societal needs is imperative to ensure that science truly benefits the people. In that context, the notion of open science is gaining increasing prominence by laying emphasis on making the entire scientific process more open, accessible, efficient, democratic, and transparent. Taking due recognition of its importance, UNESCO has also been promoting open science and open data policy over the past few years, yet there is a lack of shared values and actions for realizing open governance. With an aim to bridge this gap, this chapter establishes a broader understanding of open science and open data initiatives in context of disaster risk reduction and governance. Through the review of existing literature, four specific cases of open governance are discussed: (1) Urban drought management in Cape Town, South Africa, (2) Urban flood mitigation in Ngaoundéré city, Cameron, (3) Typhoon Haiyan in Philippines, and (4) Hurricane Sandy in the United States. Synthesizing the key lessons derived through these cases, the chapter discusses the emerging trends, existing challenges, and opportunities to enhance the operationalization of open governance in disaster risk reduction.

Keywords Open governance · Open science · Open data · Disaster risk reduction

9.1 Introduction

Since the dawn of ages, the world has been continually afflicted by countless disasters. Very often today, some disasters affect different parts of the world, such as typhoons, earthquakes, volcanic eruptions, tornadoes, tsunamis, floods, and many more. Even the Holy Bible spoke about disasters such as the flood during the time of Noah and many others. By the passage of time, the world has continued to be struck by disasters that took many lives and destroyed unquantifiable amounts of property. In the

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data collected from various sources, including UN agencies, non-governmental organizations, insurance companies, research institutes, and press agencies, the United Nations Office for Disaster Risk Reduction (2019) estimated that from 1900 alone to the present, about 18,000 mass disasters have afflicted the world. Specific disasters that took few lives and merely destroyed properties no matter what extent were not even included in these data.

Since disasters are natural phenomena that could occur unexpectedly, its governance has been a great challenge. While technological advancements have gradually been put in place, nothing can really predict accurately when these disasters will strike and how much damage they would create. The only things that the government can utilize are the predictive data prior to the occurrence of the disaster, and the remnants found after the disaster. Using these data, assessments and risk reduction plans may be created and used as a basis for preparing for the next turbulence. Since these data are crucial in reducing the risks and threats that disasters may bring, making the government more accessible to everyone is believed to be beneficial. This is the principle of open governance. Ultimately, open governance comprises three significant domains, namely: crisis management, environmental governance; and, security control (Meijer et al. 2019). These domains are relevant to the aims of disaster risk reduction as they are all intended towards the betterment of the government and general public, even after disasters.

Over that background, this chapter primarily aims to establish the significance of open governance in view of disaster risk reduction. Specifically, it presents the significant role of open science and its different components to understand the concept of open governance better. Additionally, the growing relevance of open data for disaster risk reduction and governance is also discussed with particular emphasis on mitigation and prevention, preparedness, disaster response, and recovery.

The need for the formal discussion of the significant role played by the principles of open governance in the aspect of disaster risk reduction has been established by its growing relevance in today's context. While disasters have always been challenging, the additional threats brought about by different problems in the world (for instance, the COVID-19 pandemic) have aggravated the necessity for transparency. The public must have general oversight of the issue in order for them to become effectively involved in the process of mitigating the risks by preparing them to respond effectively to disasters. Moreover, the access to open data on the governance of disaster risk reduction would also play a massive role in helping them recover after the disasters.

9.2 Understanding Open Science and Different Components

As per UNESCO's definition, "Open Science" refers to the movement that aims to bring science closer to society by providing access to the scientific process and its output. Aside from making it open and accessible, this movement also fosters

efficient, democratic and transparent scientific processes that will enable people to utilize the resources in the digital world. Basically, Open Science aims to connect ideas through the engagement of the people. It means that there will be a continuous sharing and exchange of information, which will widen the dissemination of data and will increase the number of informed and knowledgeable individuals.

Under the umbrella of the term Open Science, the core concepts and principles included are Open Access, Open Data and Open to Society. Open access refers to the accessibility of the data and outputs. Open Data pertains to the reliability of the data gathered, while Open to Society refers to the active engagement of all relevant stakeholders are the core concepts and principles. There are also other concepts such as Open Peer Review, which are governed by Open Science policies. But in general, open science primarily aims to break the social and cultural barriers to sharing and adheres to the philosophical perspective that access to research data as well as to its publication and dissemination should be openly shared to uphold the human right to science. It is also believed to bridge the gap in the realms of science, technology and innovation.

Open Science is perceived as advantageous in the realm of research, not only for the readers but also for the content creators as well. This will open the opportunities to publish more papers leading to an increased number of citations. Since research is continuous, scientific networking will also be enhanced while the research field evolves faster. These advantages would give the people more chances to become part of the networked science, and their contribution will basically add to the body of knowledge on particular concepts and principles. Practically speaking, everyone can actually contribute and at the same time benefit from Open Science.

Furthermore, Open Science is also believed to eliminate the technological and financial barriers to science. This means that it promotes reproducible research, open-source software as well as open licensing and file formats. It can be denied that even if the different digital platforms have the capacity to publish and store a great deal of information, problems with access have been a barrier. For instance, some significant research, which are not intended for reproduction, can lead to problems with its utilization and even in the citation. This scenario creates limitations on how researchers will be able to share the information and to make the best out of each assessment and analysis in the parallel studies that they do.

However, there are still some identified disadvantages with this open access to voluminous research data. Firstly, the lack of guidelines and standards for this data sharing could lead to unclear security and protection of the data source. The open infrastructures, as well as internet connectivity, may not be equally accessible to all, which can also defeat the valuable purpose of Open Science. These problems could possibly become administrative burdens of the Open Science practices and should not also be overlooked.

But if these limitations can be properly addressed, the potential benefits of Open Science are much more significant. The efficient and transparent scientific processes should be shared to maximize their significance and to bring it to a greater number of individuals who need them, especially in dealing with their real-life problems.

9.3 Growing Relevance of Open Data for DRR and Governance

Disaster risk reduction (DRR) is a systematic approach to identifying, assessing, and reducing disaster risk and helps minimize the vulnerability of a society or community (Tuladhar et al. 2015). It prevents or mitigates the adverse effects of natural disasters, facilitating a sustainable development process. DRR is particularly essential to sustain the achievements of all kinds of development goals since it provides a safety net for the hard-earned development gains of a developing country (Walshe and Nunn 2012).

DRR requires good governance as the aims of this approach are intended for mitigation and prevention, preparedness, disaster response and recovery. In such a governance approach, critical assessment of relevant data should be made in order to come up with valuable decisions that will bring desirable results, specifically in times of disaster. A local knowledge system is composed of different knowledge types, practices and beliefs, values, and worldviews. As such, local knowledge and practices need to be understood as adaptive responses to internal and external changes which result (or not) in disaster preparedness at the local level. In order to identify local knowledge on disaster preparedness, one should focus on four key aspects: people's ability to observe their local surroundings, people's anticipation of environmental indicators, people's adaptation strategies, and people's ability to communicate about natural hazards within the community and between generations (Deken 2007).

Overall, the disaster preparedness of a community needs to be understood within the broader context of livelihood security and sustainability and building up community resilience in the long term (Deken 2007). DRR initiatives have been undertaken to build resilient communities and to reduce their vulnerability to disasters following several approaches and frameworks that have been explained in literature such as a system for detection and monitoring, a system for effective communication, a system for providing assistance for rebuilding facilities, a system for response and recovery, among others.

Open governance is perceived to be beneficial in terms of DRR as it will promote openness of data, data quality assurance and open participation (Haworth et al. 2018). The openness of data would make the governance democratic and collaborative as the people would be able to have access to the data gathered and could also help in assessing them. Because of the reliability established by the data that have been confirmed by the people themselves, the quality will be assured. In these two processes, the participation of the people would be evident. Additionally, open governance will not only enable the people to get involved but it will also help in the adaptive learning process leading to the creation of more satisfying solutions (Hudson 2016).

The increasing trend in using open data and open governance in DRR is believed to be more contributory in the attainment of the aims of the program. Open data reproduce reliable information on disasters and other components that are relevant to it. Open governance, on the other hand, maximizes the participation of the people

who are the ones directly affected by the disasters. This participation is believed to enhance their knowledge and preparedness to mitigate or prevent the risks brought by disasters.

9.4 Open Governance for DRR: Case Study Examples

Over the past decade or so, global trends have shown that disaster events are becoming a turning point in open governance for DRR. As an essential tool for information sharing, open data is being broadly applied for enhancing disaster mitigation and management. The Ushahidi Haiti Project (UHP), set up during the 2010 Haiti earthquake, is a widely recognized attempt at using crowdsourced mapping to manage catastrophic emergencies, which also revealed the potential of digital humanitarian response in disaster relief activities (Ushahidi Staff 2010; Meier 2011). Volunteers were recruited to sort and geolocate the messages collected from social networks, mainstream media, and a specialized SMS hotline that provided text messaging services for victims in Haiti. This was done with technical support from local telecom companies and translation aid from worldwide Haitian expatriates. And then, a real-time online map of actual demands based on the received information was created (Norheim-Hagtun & Meier 2010). In total, more than 40,000 different reports were processed for the earthquake, and the public crisis map visualized 3,584 events (Morro et al. 2011). Since then, there has been widespread use of digital technologies around the world in open governance for DRR. For example, the Mabi Care platform was formed after the catastrophic flooding in Southern Japan in 2018 to spread constantly updated information on "life and health" provided by the local population, namely the availability of emergency medical care and the operation hours of restaurants, convenience stores, bathrooms, etc. (Mabi Care 2018). Even during the ongoing COVID-19 pandemic, many countries have launched Internet-based projects to make full use of citizen science in outbreak management (Open Government Partnership 2020).

Taking account of the widespread technological advancements and their growing application in DRR, this section is mainly intended to understand the current trends of open governance and the potential for upscaling these practices. The following four sections present a review of four specific cases. They demonstrate how diverse stakeholders collaborate under open governance approaches to help individuals, organizations, and governments make thoughtful and timely decisions to save more lives and reduce disaster losses.

9.4.1 *Open Data in Drought Management—Case of Cape Town, South Africa*

9.4.1.1 Overview of the Cape Town Water Crisis

Since 2015, the city of Cape Town has been experiencing its worst water crisis for centuries. The cause of it has been attributed to several reasons such as reduced rainfall, increased water demand of a rapidly growing population, a surge in water-absorbing alien plants, and rising temperatures (GCTWF 2018). Often, the drought severity is measured based on the water level of the city's major dams, through which it meets its water demands. Correspondingly, in January 2018, the Mayor of Cape Town announced that in three months, Cape Town could be approaching "Day Zero", the day when the reservoir level of the main dam could drop below 13.5% (City of Cape Town 2018). The "Day Zero", in general, was locally referred to as the time when each Capetonian could only collect 25 L of water a day at 149 water points. Against that backdrop, substantial efforts were made throughout the city to enhance the water supply and reduce the water demand to alleviate the water crisis. As a result, the expected "Day Zero" was postponed to 28 June 2018 (Said-Moorhouse 2018; Mumbere 2018). This was also complemented by the revival of rainfall, as the worst of the drought came to an end in September 2018, when the dams' water level neared 70% capacity (Pitt 2018). Even though the water crisis had a massive impact on Cape Town's economy, public health, and citizens' livelihoods, open data played a key role in drought governance, the precise aspects of which are discussed in the following section.

9.4.1.2 Data Crowdsourcing and Citizen Participation

The city's Open Data Portal was initiated in January 2015 as a joint effort between the Mayor's Office, the City's Development Information and Geographic Information Systems (DI & GIS) Department, the Western Cape's Member of the Executive Committee (MEC) for Finance, Economic Development, and Tourism (Willmer et al. 2015). Its launch was part of Cape Town's Broader Digital City Strategy, which aims to use digital technologies to improve the level and quality of services provided to the public, encourage civic engagement, and eventually make urban management more inclusive, citizen-centered, and concerned (City of Cape Town 2014, 2016).

During the prolonged period of drought, the active contribution of the citizens in open data initiatives considerably helped save the Cape Town city from approaching "Day Zero". In consideration of the fact that the aging water supplies were leading to significant water losses, a multi-channel mechanism was set up to facilitate Capetonians to report facilities in need of repair and other problems associated with water losses through mobile SMS/MMS, voice mails, social media and web form (Van Belle and Hlabano 2019). Through this mechanism, all forms of reports were welcomed, especially those with a GPS location and attached pictures. After receiving the

incoming reports, a special team prioritized and distributed them to on-call maintenance staff. As a result, the mainline leaks could usually be treated within 60 min. Account of the quick and organized response, water losses related to poor water infrastructures were reduced from 25 to 15% by early 2018 in Cape Town. More notably, the Capetonians also pushed the government to raise punitive water tariffs for high water consumers and lower the same for low water users through active participation on social networking platforms. These collective actions were beneficial for water conservation during the severe drought and enhanced urban equality.

9.4.1.3 Identified Challenges

(a) Cape Town has a high Gini coefficient, indicating a wide income gap between rich and poor residents. Poverty can directly lead to deficient access to the internet. It was reported that up to 79.3% of Capetonians have no internet access (Statistics South Africa 2018). The disproportionate distribution of Internet users in Cape Town creates a "digital divide", a term describing the disparity between people who have access to and benefit from affordable and secure internet services and those who lack them (Dijk 2006). This indicates that wealthy Capetonians, who are more likely to have sufficient internet access, more advanced digital devices, and higher digital literacy, are more presumably to report problems to the open data platforms than those who do not. In such circumstances, it is more difficult for the poor and vulnerable citizens to be heard and their needs to be identified. Therefore, the digital divide needs to be addressed so that every citizen can participate in open governance by contributing open data. The local government could consider minimizing the vast digital divide by upgrading hardware devices, enhancing residents' understanding of digital communication mythologies, and reducing the cost of accessing the internet.
(b) Since this series of cooperative actions was launched after a prolonged drought, it remains to be seen how effective citizen participation in government and public decision-making and disaster mitigation will be in normal times or the face of other types of disasters in Cape Town. Given the increasing trends of urbanization, Cape Town could yet fall back into an acute drought at some point in the future. Thus, there is a need to improve information disclosure during non-crisis times, which could advance urban infrastructures and prevent disasters and help facilitate faster response and better decisions when disasters occur.

9.4.1.4 Key Lessons

(a) The collective action of Capetonians in improving the cities' open data was found to be effective in timely reporting of problematic water utilities and other loss-related issues. Moreover, it appeared to have effectively influenced

government policy decisions to keep the city away from "Day Zero". Cape Town's success in tackling the water crisis may have implications for policies and strategies in other places facing similar challenges. However, given that each city has its unique economic, historical, cultural, and geographical background, so corresponding countermeasures need to be formulated according to these specific conditions.

(b) In addition to open data and citizen engagement, Cape Town's success in avoiding water depletion was impossible without policy support, technological intervention, media management, and adequate funding. In terms of promoting the positive impact of open data on capacity development for DRR and encouraging civic engagement in open governance, future actions should also aim to improve open databases' quality, accessibility, and design and encourage greater use of open data. This could be done by raising citizens' awareness and enhancing their technical ability to interpret data. More than that, fundamental issues such as unsustainable urban planning, environmental degradation, significant income disparities, and digital divide should also be addressed to further raise Cape Town's urban resilience in the face of future water shortages.

9.4.2 Open Data in Urban Flood Mitigation—Case of Cameron

9.4.2.1 Vulnerability of the Ngaoundéré City

Ngaoundéré is a disaster-prone city in the Republic of Cameron. It faces recurrent floods, landslides, and water erosion on hillslopes, especially during the rainy season. The unrestricted expansion of urban regions is further intensifying these risks. This is partly because many new neighborhoods are being built in the peri-urban areas, such as floodplains and rocky hillsides (Tchotsoua and Bonvallot 1999; ACAGER 2019). Due to Ngaoundéré's location at the Sahelian margin, the city is also highly vulnerable to the devastating effects of climate change, pollution, and damaged natural ecosystems, which are consequently leading to other concerns of food and water crisis, economic problems, and ruined livelihoods (The World Bank Group 2019). There is growing awareness of the need for practical tools to improve the situation, such as updated and open access maps, to help make open data available to a broader population and assist local DRR.

9.4.2.2 Project "Open Cities Africa—Ngaoundéré"

Open Cities Africa is a project of the Open Data for Resilience Initiative (OpenDRI), launched by the Global Facility for Disaster Reduction and Recovery (GFDRR), in partnership with the World Bank Africa Urban, Resilience and Land Unit and financially sponsored by the European Union's Africa Disaster Risk Financing (ADRF)

(GFDRR 2020). The project aims to develop up-to-date geospatial data to support effective decision-making in disaster risk management. It was designed to enhance local capacity and foster collaboration among stakeholders, including civil society and the private and public sectors, by making full use of accumulated data.

Ngaoundéré was chosen to be one of the first nine cities to join the Open Cities Africa project, and it was initially announced at the city council in August 2018. The Urban Community of Ngaoundéré (CUN) was required to improve the open spatial data to contain built areas and essential infrastructure, particularly near the beds of major rivers (ACAGER 2019). These data were considered helpful for sustainable urban planning, rational land use, and protecting the city from various natural disasters. In order to complete a user-friendly Risk Atlas, the Open City Ngaoundéré project encouraged the participation of multiple stakeholders from the offset. Association for Cartography and Resource Management (ACAGER) carried out a collaborative mapping process with the active involvement of 33 local groups, including government organizations, local communities, students from local universities and geography, topography, cartography, and economic experts, with a particular focus on gathering data on the flood-prone areas. The project involved local volunteers, including several college students, who received free but professional online and offline training in data collection, mapping, and analysis. Sharing of course content is encouraged to increase citizen knowledge of disasters. In addition, communication training was also provided to the participants before they approached the local communities for field surveys. Not counting the online activities initiated by the Open Cities Africa, a total of 17 local training events were held in Ngaoundéré, which contributed nearly 264 mappers directly to the city (GFDRR 2020). Within two months, a total area of 39,000 ha with over 35,000 different objects, ranging from essential facilities to water points and streets, were mapped on OpenStreetMap (OSM) for everyone to use (ACAGER 2019). A paper version of the city map was also released to fulfill the requirements of the local communities.

Moreover, the Open Cities Ngaoundéré team also paid attention to ensuring the map's quality, which was done under the supervision of the Cameroon OSM Association. Maps on OSM can be compared with datasets from official agencies and the latest satellite images. The "Gap Detection" feature on the mapping tool also allows the user to visualize potential gaps (OpenStreetMap Analytics 2021). As of November 5, 2021, 89,741 buildings, 6,675 km of highways, and 214 km of waterways in Ngaoundéré have been edited on OSM (Open Cities Africa 2021).

9.4.2.3 Identified Challenges

(a) While the Open City Ngaoundéré project has positively impacted local governance, several specific challenges have hampered its implementation. Technical difficulties like poor internet connection, lack of GPS tracking, and low-quality data from Bing Imaging and World ESRI were pointed out as needing improvement at similar events (ACAGER 2019). The financial investment to solve hardware and software problems is also necessary. Governments and other investors

should realize the value of funding them for the fact that technology and open data are believed to provide fundamental solutions to many of the world's long-term problems, though their impact is not always immediate and takes some time to manifest.

(b) Detailed geographic data are crucial to delivering the required service to the right person at the right time. Yet, there are still more than a billion people worldwide who are currently missing from digital humanitarian maps (The Audacious Project 2020). Their families and even entire communities are not recorded in the database, preventing them from accessing adequate public services. Many of these unmapped areas are vulnerable to disasters or experience multidimensional poverty. It is challenging to deploy humanitarian staff effectively to bring life-saving assistance and life-improving services to vulnerable areas during disasters without maps. Thus, more action should be taken to map individuals and communities that have been left out to minimize global inequalities and leave no one behind.

9.4.2.4 Key Lessons

(a) The open City Ngaoundéré project has helped develop an open map dataset, which could serve as a foundation for constructing a disaster-resilient city that allows all residents to live in a better and protective urban environment. The project's success is mainly due to its collaborative nature, which recognizes the value of multiple stakeholders in enhancing local resilience concerning their needs and their willingness and ability to participate in urban governance and local DRR. Greater involvement of citizens can ensure the timeliness of information updates and promote wider dissemination and use of information, thereby improving the quality of open data on the online platform and having a positive impact on open governance. Experienced ACAGER workers suggested that this could be achieved by promoting the training of non-university students in cartographic knowledge and techniques by relevant institutions, such as bilingual training centers and municipalities. In addition, local leaders should develop a more open urban culture and continuously promote community contribution and the use of open data.

(b) In addition to reducing the flood risks by providing timely disaster information to the vulnerable communities to generate a rapid response, the initiative has also helped the local authorities with improved urban planning and securing funding from the central government for local DRR. The project maps have also been broadly used for other purposes to tailor the needs of various stakeholders. For example, the city council plans to establish an own-source revenue to support local financial activities (GFDRR 2020). And under the Inclusive and Resilient Cities Project (PDVIR), the geospatial data have also been applied to underpin infrastructure designs at the neighborhood level. Furthermore, the stored data are also used for scientific research and teaching activities in local academic institutions. Besides, the success of the Open City Ngaoundéré project has inspired

several other African cities, such as Yaoundé and Douala (Zaengerling et al. 2021). Similar open risk mapping projects have been undertaken in these cities, and the project training content has already been used to map four cities in Cameron and Chad.

9.4.3 Case of Typhoon Haiyan 2013 in the Philippines

9.4.3.1 Introduction of the Event

Super Typhoon Haiyan, the 30th named typhoon of 2013 Pacific typhoon season, was recognized to be the most robust tropical cyclone in the world in 2013 and the third most robust tropical cyclone on record in the Northwest Pacific, after Typhoon Nanshi in 1961 and Typhoon Tip in 1979 (Fischetti Mark 2013). It was generated in the northwest Pacific Ocean more than 1,100 km southeast of Guam on November 4. It continued to strengthen as it traveled westward. According to the U.S. Joint Typhoon Warning Center, it reached maximum winds of 75 m/s when it was active near the south-central islands of the Philippines and carried violent storms at speeds of more than 300 km per. The frontal attack of Typhoon Haiyan on the Philippines brought gale-force winds, heavy rains, and huge waves, causing heavy floods, landslides, and mudslides in the south-central part of the Philippines. Several towns and villages were washed away; flights were grounded, ports stopped operating, water and electricity were cut off in some areas, and paralyzed communication (Reuters 2013). A report released by the Philippine National Disaster Risk Reduction and Management Council on December 13 stated that 41 provinces were hit by Typhoon Haiyan, which affected more than 13.4 million people in varying degrees, killing 6,054 people injuring 26,922, and leaving 1,820 missing. Moreover, the typhoon destroyed nearly 600,000 houses, damaged more than 610,000 houses, and left almost 4 million people homeless. As Typhoon Haiyan, the strongest typhoon in history wreaks havoc on the Philippines, open data played a crucial role in the post-disaster rescue, the specific aspects of which are discussed in the following section.

9.4.3.2 Open Data and Citizen Engagement

The National Hazard Operational Assessment of Hazard (Project NOAH) was launched in 2012 by the Philippines for DRR and prevention. In order to disseminate critical information of Typhoon Haiyan to as many people as possible, the NOAH project developed a web-GIS using freely available source code and application program interfaces (APIs). This web-based GIS tool is now used extensively by local governments in DRR and prevention. What's more, OpenLayers, an open-source dynamic mapping platform is used on the NOAH project website to embed Google's web mapping service and other online mapping services such as OpenStreetMap into web pages. Using this platform, timely and accurate solutions to

disasters in the Philippines are possible. Many researchers used the website OpenLayers to make different predictions about Typhoon Haiyan (Alfredo Mahar et al. 2017).

During the disaster, citizens also used open data to make positive contributions, which helped the Philippines weather the disaster. Google has created Google Crisis Response, a Google map for the post-disaster rescue in the Philippines. It not only shows the path and location of Typhoon Haiyan but also indicates evacuation centers, disaster areas, rescue centers, and distribution centers data in the Philippines; The Standby Task Force, a volunteer web-based software development team, formed to respond to the disaster, has used the Micromappers platform to create another Google Map of the Philippines disaster response, the SBTF Crisis Map, where residents can see the damage, the relief services and health conditions of the cities. Further, the Project Agos Disaster Information Map, produced by Rappler, provides rescuers with data from disaster areas and information on hazards from road traffic, construction, and flooding (MicroMappers 2011).

9.4.3.3 Identified Challenges

(a) The maps based on open data help citizens act promptly and accurately. However, there is a possibility of unauthorized and false information on the map information. The information that lacks sufficient facts and data makes it difficult for citizens to distinguish between truth and falsity and make it difficult for people to find sources of information and guidance they can trust, what's worse, making it possible to cause panic, misplaced rescue, and unnecessary social trust crisis in post-disaster recovery.
(b) While current information and communication technologies have rapidly improved and the open data research and infrastructure for the Philippines has grown in both quality and quantity, there is still a need for improvement, such as how to make open data more accessible to more people and how to make more open data-based science and technology innovations and how to stimulate more technology innovation based on open data, etc.
(c) What's more, the issue of funding to maintain technology and equipment cannot be ignored either. In January 2017, the project NOAH was shuttled down by the Philippines government because of fiscal issues; although it continues to be operated by the University of the Philippines, the funding issue facing the future use and maintenance of open data is still a significant dilemma.

9.4.3.4 Key Lessons

(a) Disaster maps based on open data provide a wealth of helpful relief information in a short period. This helps official agencies to focus on relief operations effectively. In the future, disaster maps will play a more critical role in disaster management. Therefore, disaster maps should classify the large amount of open

data collected from social media and sensor networks to provide the appropriate personnel (Fakhruddin et al. 2019). Taking the example of Haiyan typhoon, map makers may need precise geographic information. Fire departments may need detailed information about injured people, and backup departments need to specify the relief materials the affected people need. In addition, for the masses, it can also provide helpful information for people near the disaster area to take better response measures.

(b) During the disaster, the quality of the information provided by publicly available data is a crucial issue. For example, during the Haiyan typhoon, many citizens exercised their civic power to "mutual assistance" by collecting information about the disaster, contacting those affected, and marking the geographic location of the rescue on a map to play a role in the immediate post-disaster response and recovery process. When there is false information among them, it can cause difficulties in information collection and rescue work. Thus, the challenge for the future is how to use open data and information for emergency response. However, the quality of information currently available from open data on the Internet is still in its infancy in emergency management.

9.4.4 Case of Hurricane Sandy 2012 in the United States

From October 28 to 30, 2021, Hurricane Sandy swept across the eastern region of the United States. It caused heavy rain, snow, and flooding disasters and caused many power and water outages, communication disruption, and traffic accidents. According to the data released by the U.S. National Weather Service, as of the evening of October 30 local time, the maximum height of the hurricane wind and waves was 4.23 m in New York. At least 17 states were severely affected by the hurricane. The property damages were estimated to be 50 billion dollars; the highest land wind speed was 225 km/h, and around 72 and lost their lives in the disaster. The impact of Hurricane Sandy was particularly severe in New York City, where the storm caused power outages to approximately two million residents. In the most damaged areas, it took several months to restore the electrical system (Holloway and Linda 2013). The storm also affected thousands of residents, injuring nearly 620 houses, affecting the basic livelihoods of 8,500 families, and creating a surge in demand for temporary housing and shelter services.

It is essential to note that the New York City government strongly relied on social media, including Twitter and YouTube, to disseminate important information during the disaster. The government agencies tweeted more than 2,000 messages and received more than 175,000 followers during the disaster (Sen et al. 2018). What's more, since the failed response to Hurricane Katrina that happened on August 23, 2005, the United States continues to reflect on the reasons for the failed response and, as a result, has had a breakthrough in its response to Hurricane Sandy. The United States has compared the reaction to these two major natural disasters in detail and found that open information resource management was one of the critical factors

affecting the success or failure of the emergency response (Yumei and Shanshan 2018).

9.4.4.1 Open Data and Crisis Response

The aftermath of Hurricane Sandy witnessed a strong sense of information sharing at the governance level, as part of which data awareness had begun to emerge so that evacuation sites and map data could be released on the open data platform promptly. This not only enhanced the emergency coordination capabilities of relevant departments, but the public was also able to obtain the latest news on emergency relief supplies and escape routes. As the process of opening government data has advanced, various open data platforms are coming online and beginning to apply government data more widely for emergency management in the United States.

When a disaster occurs, rescuers inevitably lag affected victims to reach the incident site, which leads to the local population being the most active information providers. In fact, the contribution of information dissemination on social media to the relief effort has been widely recognized in the case of Hurricane Sandy. Twitter messages showed that people began to prepare for the impending storm through media alerts, such as charging cell phones and purchasing emergency kits, candles, flashlights, generators, and backup power supplies at retail stores. The number of statements about disaster preparedness peaked on October 28, after the President Barack Obama declared an emergency in New York City. On October 29, information releases were dominated by topics related to preparedness and no information about emergency response to disasters. The peak of these preparedness-oriented messages was on November 29. There was also a spike in the number of tweets posted regarding disaster recovery information, with a greater focus on volunteering and post-disaster reconstruction on November 10 (Sen et al. 2018).

9.4.4.2 Identified Challenges

In a complex rescue environment, achieving effective information sharing and collaboration among participating emergency response subjects has long been a challenge for emergency management. When an emergency occurs, in order to respond and handle the emergency effectively, it is necessary to ensure that all response subjects can get the required information promptly. The lack of proper communication and channels to receive relevant information indicates that the current emergency management information sharing is not enough to meet the needs of emergency collaboration. It is necessary to improve information sharing to promote the smooth development of the emergency collaboration (Nunavath and Prinz 2017).

By screening, identifying, filtering, and analyzing social media, open data from Hurricane Sandy, provided helpful information to promote disaster prevention and mitigation, becoming a new tool for disaster monitoring and recovery. However,

social media open data in urban disaster prevention and mitigation also has its limitations. Especially when online information does not match the actual situation, there is a need to supplement disaster information reported through conventional channels. At the same time, targeting different income groups and using data from social media platforms to release adequate information and provide assistance will become a direction worthy of attention in future disaster recovery efforts through open data.

9.4.4.3 Key Lessons

(a) The opening of government data provides the primary conditions for emergency information sharing, which makes the process of emergency collaboration more flexible and effective. In fact, the effective response to Hurricane Sandy is also reflected in the improved communication between governments and the adequate preparation of relevant government departments for hurricane landfall. New York's open data platform released evacuation sites in advance, which appeared more efficient in resource deployment and material dispatching, allowing for improved emergency collaboration between governments; continuous monitoring of public demand and timely discovery of where it would flood and or where power would be lost facilitated the flexible dispatch of resources and flexible allocation of field staff.
(b) Social media can provide a wealth of information and can also provide near real-time responses. Social media big data has the advantages of rapid response, spontaneous feedback, and low acquisition cost in urban disaster prevention and mitigation. We can learn from the case of social media extensive data application in the United States and use the big data from social media in all aspects of pre-disaster warning, disaster relief, and post-disaster recovery as a valuable supplement to traditional information acquisition channels to establish a rich, three-dimensional, and comprehensive disaster information database to help decision-makers and planners provide a basis for the preparation of reconstruction planning.

9.5 Key Challenges in Operationalizing Open Governance

Unrestricted use and sharing of government data are conducive to strengthening emergency management capacity, improving emergency management levels, and promoting social development. However, under the constraints of various factors in modern society, the operationalization of open governance in emergency management still suffers from insufficient data application capacity, substantial data barriers, information security concerns, lack of emergency management education, and other problems. The following sections discuss a few of the critical challenges.

9.5.1 Digital Divide in the Disaster Management

Social media data for emergency and disaster purposes are critical during a disaster situation. However, the social media data do not always account for the diversity of population groups Some participants who have access to social media use it to quickly get relief and help from disasters, while others who do not have access to relief through social media struggle. In this sense, the "digital divide" can amplify social inequality, leading to potential "second-order disasters". This refers to the fact that there are more severe human-perpetuated disasters beyond the effects of natural disasters. In the case study of Cape Town, the city has a high Gini coefficient, with a predominance of poor people and a polarization of Internet users in Cape Town, creating a "digital divide". Disaster relief and needs from poor and vulnerable citizens will be more challenging to detect in this context. Madianou (2015), through interviews, explored how disaster victims recovered in their daily lives. A clear "digital divide" was observed that mapped onto existing social inequalities. The households most affected by the disaster during the typhoon are still living in temporary housing such as unsafe tents or shacks erected in the affected townships in the no-build zone. From her first visit to the most affected communities in April 2014 to the 6 months after, the living conditions of many low-income victims remained virtually unchanged, confirming the delayed recovery in the "digital divide" for low-income victims (Madianou 2015).

9.5.2 Technical Difficulties

Although the current information and communication technology has been rapidly improved, there are still some forward-looking problems that need to be urgently studied and solved, such as relatively weak awareness of science and technology participation in response to major emergencies, relatively low investment in science and technology, relatively slow research and development of critical technologies and their products with insufficient reserves and relatively low levels of configuration, relatively low levels of prediction and forecasting of some major emergencies, relatively low prevention and control capabilities, relatively low levels of emergency management, and countermeasure strategies that cannot be integrated and introduced promptly. As in the Open City Ngaoundéré project, technical difficulties such as poor Internet connectivity, lack of GPS tracking, and low-quality data from Bing Imaging and World ESRI needed improvement.

9.5.3 Insufficient Data Application Capacity

With the increasing prevalence and accessibility of networks, the massive data resources bring multi-faceted opportunities for the development of emergency management. Yet, there is still a lack of high-quality data applications. On one hand, non-digital information such as newspapers, pictures, and books often lack compatibility between their respective attributes and formats and cannot be processed quickly and effectively using modern information technology, making it difficult to extract, store, manage, and apply. On the other hand, the application of correlated emergency management-related data is also weak. Most government emergency management makes scientific decisions for emergencies in an extraordinary situation and within a limited time, which requires strong data integration, capture, and analysis capabilities to support it, but this is not the case. For instance, the Philippine government had forecasts for the typhoon before it made landfall, and mandatory evacuations were implemented in certain areas. However, the most significant casualties and infrastructure damage were not caused by the strong typhoon but by the tsunami-like high waves caused by the typhoon. In the hardest-hit city of Tacloban, all buildings were destroyed by the waves along the coast to 1 km inland, including temporary evacuation facilities such as schools, churches, and municipal facilities. These buildings were filled with many evacuees, resulting in a heavy loss of life and injuries.

9.5.4 Limitations of Social Media

The application of social media big data in urban disaster prevention and mitigation has many advantages such as rapid response, spontaneous feedback, and low acquisition cost. However, its application in urban disaster prevention and mitigation also has its limitations. In particular, when online information does not match the actual situation, it is necessary to supplement the disaster information reported through conventional channels. Sen (2018) analyzed the application of information on Twitter during Hurricane Sandy, showing that there may be no or a small population in landmark locations, such as airports, large parks, and green spaces. Still, the number of tweets posted is very high. It is easy to see that many tourists and the non-resident population are responsible for the vast amount of information and that tourists may have more time to post information than the people who are affected (Sen et al. 2018). Thus, in analyzing data with the help of social media, identifying those who need rescue is the difficulty and focus of extensive social data analysis. To use social media to disseminate real-time information or focus on feedback in emergencies needs to consider that social media information is not exactly like the real situation of actual disasters and requires the screening, analysis, and identification of these spontaneous data to contribute to the disaster prevention and mitigation process indeed.

9.6 Key Lessons and Opportunities

9.6.1 Bridging the Digital Divide

How to avoid the "digital divide", how to provide information to the elderly, people with disabilities, people who do not speak the local language and cannot access social media, and how to provide information to multiple social media at the same time are also issues that need to be addressed in operationalizing open governance. There are many technical tools available for the simultaneous delivery of DRR information through social media. Still, traditional channels like television, radio, newspapers, etc., cannot be ignored for those who cannot access social media for various reasons. Typhoon Haiyan may not have been a second-order disaster, but if issues related to recovery policies and the social "digital divide" are not addressed, delayed recovery could become a second-order disaster. Information infrastructure is the carrier of information dissemination. It is only through an integrated urban-rural information network that citizens scattered in poor areas can realize simultaneous real-time sharing of various information resources. Therefore, the construction of infrastructure, including virtual networks and network access conditions, Internet access equipment, and Internet access sites, is a prerequisite for overcoming the issue of the "digital divide" (Chen 2014). The increase of capital investment and the promotion of information infrastructure construction will play a crucial role in eliminating the impact of the "digital divide" on open governance in the future.

9.6.2 Government Support for Technical Issues

Government support is critical for technical innovation in disaster risk management, including early warning and DRR analysis technology. The early warning provides information in advance of emergencies so that people can act early to reduce risk. To sustain a complete and adequate early warning system requires strong political commitment. Long-term institutional safeguards are needed, depending on sufficient government attention to science and technology and stable funding. For example, the NOAH project, established in the Philippines for disaster preparedness, was forced to be discontinued due to insufficient funding. In order to prevent such an event from happening again, the government needs to control the balance of investment funds for disaster prevention. Second, investment in analysis technology is also necessary. As with Typhoon Sandy, the massive use of social media helped save many people affected by the disaster. Social media is now increasingly being used by disaster victims, rescuers, and volunteers to share and access information about the disaster in order to provide better help. In addition, relief agencies are using it for emergency contact and recruitment of volunteers. The governments need to build on its use of social media and analytics platforms and further invest in technology to lay the foundation for better big data analysis and disaster management (Qiyu 2014).

9.6.3 Multi-Partnership Collaboration Toward Emergency Response

The above case studies show that the "citizen collaboration" model of emergency management has become essential for effective response to emergencies. In the early stage of emergencies, relevant government departments need to cooperate with creative social groups or the public to develop data products and services for emergency management, such as applications for public emergency knowledge popularization, real-time map software for rescue. When an emergency occurs, the public can try to save themselves and each other in the community, based on the information they get; rescue teams can get accurate information for rescue in time to carry out precise rescue, and external assistance forces such as other government departments or the public can understand the needs of the affected area and send help in time. After an emergency occurs, the objective data generated by the emergency management process can also become an essential basis for judging the reasonableness of the government's decision-making behavior, monitoring the government's emergency decisions, and changing the standard emergency management evaluation model.

9.6.4 Capitalizing on the Social-Media Big Data

In addition to traditional disaster detection methods, social media data can be an essential tool for collecting and feeding back urban disaster information. Although social media data cannot be directly applied in post-disaster reconstruction planning, it is indispensable for urban safety system construction. Disaster prevention and mitigation planning as social media data can be mined too quickly and accurately obtain information on disaster locations, the extent of damage, and characteristics of affected people, which provides essential introductory information for rapid response, rescue planning, and post-disaster recovery planning after disasters. For example, the use of Twitter data to fight against Hurricane Sandy in the United States showcases the role of social media data in disaster prevention and mitigation as a valuable supplement to traditional information access channels, which will provide a reference for enhancing urban safety and continuously improving urban disaster prevention and mitigation capabilities.

9.7 Conclusions

Even though the notion of open governance is still evolving, the importance of open science and open data initiatives is increasingly being recognized for enhancing the disaster risk governance worldwide. This chapter set out with an aim to establish a broader understanding about the growing application of digital advancements for

driving governance in disaster risk reduction. Through the review of four selected case study examples, it has become clear that the digital technologies (like the use of social media) are increasingly supporting the transition towards open data with active engagement of all relevant stakeholders. While the multi-faceted benefits of these transitions are apparent in form of inclusive data sharing and transparency, a diverse range of challenges still continue to hinder their large-scale utilization for governance in DRR initiatives. Regardless, the chapter stresses that the benefits of open governance far overshadow their disadvantages, if certain key shortcomings could be overcome, like that of data security and integrated assessments. By ensuring the wide access of scientific data and by enhancing citizen engagement, open governance initiatives can help to tap the unexplored potential of whole-of-society approach in DRR.

Towards the end, the authors acknowledge that this research is mainly based on the review of existing literature, and there is a huge potential of exploring real cases based on original data and research exercises. Especially, in the backdrop of the ongoing COVID-19 pandemic, there has been a growing emphasis and reliance on technological tools towards the facilitation of in DRR efforts. While the specific findings derived through the review of four case study examples in this chapter may not be generalizable, the identified broader challenges and opportunities can guide future research on enhancing open science and open data initiatives. Further research can also be conducted in the areas of enhancing data security and validating fake information.

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Chapter 10
Open Governance and Disaster Planning, Recovery, and Response: Lessons from the United States

Patrick S. Roberts, Shalini Misra, and Mark Goldberg-Foss

Abstract Open governance initiatives in disaster management in the United States have three related aims: (1) communicating and interacting with the public, (2) improving decision-making at the community level, and (3) improving collaboration among governments and government agencies. At its best, open governance improves government performance and empowers residents in disaster situations. To succeed, however, open governance must include sufficient local capacity to acquire, input, and use shared data, and enhance accountability along with performance. The social media environment that enables more openness and collaboration can also give rise to rumor and misinformation. Emergency managers and others in disaster situations will need to address misinformation directly. This chapter reviews the literature on open governance and disasters and compares three cases of the use of open governance technology in the United States to provide recommendations for improving transparency and accountability.

Keywords Open governance · Disaster response · Disaster planning · Technology and disaster · HAZUS

10.1 Introduction

Open governance initiatives in disaster management in the United States have followed from larger government initiatives aimed at making data public and using digital technologies including social media, but they have found distinctive expression in the management of disasters. As characterizes governance, the initiatives include government actors, nonprofits, private businesses, and residents who together aim at disaster planning, response, and recovery goals. The United States' large size, overlapping jurisdictions including constitutionally independent states, and diversity of hazards make open government initiatives particularly promising for improving coordination and collaboration. The centrally planned and coordinated assumptions

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of some disaster planning efforts may be insufficient, and more bottom-up coordination, flexibility, and improvisation are required in rapidly evolving disaster situations (Comfort 2007). Open governance initiatives provide the data and digital tools for these bottom-up and flexible initiatives.

Drawing from the broader literature on open governance in public management, this chapter conceptualizes open governance in disaster management as a public management reform initiative (Ingrams et al. 2020). It classifies disaster management open governance initiatives according to three interrelated aims in disaster policy and focuses on the role of digital technologies in these initiatives. Open government initiatives in disaster management aim at (1) communicating and interacting with the public, (2) improving decision-making at the community level, and (3) improving collaboration among governments and government agencies. Open governance has achieved each of these three aims to some degree in the United States, but it has also faced challenges. This chapter concludes with an analysis of the ways in which open governance can improve government performance and empower residents in disaster situations. At the same time, it must also address issues of local capacity to engage with shared data, the cost of data acquisition and input, and tensions between government accountability and enhanced performance. Finally, the social media environment that enables greater interactivity can also give rise to rumor and misinformation, and emergency managers and others in disaster situations will need to address misinformation directly.

10.2 Theory of Open Governance in Disaster Management

Open government is an approach to public management that links the openness of data and processes with reform and improvement (Ingrams et al. 2020). It centers on three principles. The first principle of open government is openness between the government and its environment, which includes government transparency and accountability (Coglianese 2009; McDermott 2010; Meijer et al. 2012; Janssen et al. 2012, Harrison and Sayogo 2014; Wirtz and Berkmeyer 2015; Hansson et al. 2015; Grimmelikhuijen and Feeney 2017; Piotrowski 2017). Public participation and collaboration characterizes another stream of the literature (Grimmelikhuijen and Feeney 2017; McDermott 2010; Meijer et al. 2012; Hansson et al. 2015; Wirtz and Berkmeyer 2015; Harrison and Sayogo 2014; Evans and Campos 2013). The third principle in the literature is leveraging information and communication technologies to democratize information access, gather and share public data and input, engage the public in decision-making, and encourage knowledge sharing (Grimmelikhuijen and Feeney 2017; Evans and Campos 2013; Janssen et al. 2012).

Scholars have argued that information sharing and communication across government agencies and sectors can improve government decision-making and promote economic growth and good governance (Ingrams 2017; Wirtz and Berkmeyer 2015). Specific legal reforms like the Freedom of Information Act (FOIA) can expose and reduce government corruption and increase trust in government (Coglianese 2009;

McDermott 2010). At the same time, policies designed to protect individuals' identity and privacy can serve to protect personal privacy and encourage government transparency (Ingrams 2017). Scholars have argued that the relational and communicative aspects of open government can encourage public participation in government decision-making at the individual level and the engagement of non-profits, businesses, and other stakeholders at the organizational level (Evans and Campos 2013; Piotrowski 2017). Some scholars find that open government initiatives allow high-tech corporations to provide government agencies with raw data, technological resources, data management and analytics capabilities to inform efficient and effective policy making (Gonzalez-Zapata and Hecks 2015).

Coglianese (2009) argues that holding public officials accountable will serve the overarching ultimate ends of democratic governance—fairness and justice.[1] Digital tools and technologies can be essential means for achieving these ultimate ends. Some scholars have argued that the digitization of information through open government increases interaction between government and the public and other external stakeholders thereby increasing transparency and accountability, which is a critical means to justice (Schillemans et al. 2013; Shkabatur 2012). Online notice and comment policies and spending transparency are some examples of the use of digital technologies to increase government-public interaction and promote transparency. Application of social media, wikis, application program interfaces, and open data, which involves pooling data from a variety of sources and allowing the reuse of data by diverse organizations, have become important ways to increase government transparency, and they encourage public participation and collaboration across agencies and sectors leading to new forms of collective action (Evans and Campos 2013; McDermott 2010; Meijer et al. 2019). Open data coupled with partnerships between the government and technology providers can lead to technological innovations that improve efficiency and effectiveness (Janssen and Estevez 2013).

In contemporary disaster planning, recovery, and response, open government initiatives have focused on the potential of advanced digital technologies and mobile networks to communicate and interact with the public, gather information from the public and mobilize people to collect, analyze, and act on that information, and exchange information between government agencies to coordinate disaster recovery and response and aid decision-making. Prior to outlining the three categories of open government approaches in disaster management, we provide definitions of key terms in Box 10.1.

[1] Public accountability refers to the answerability of government, as a statutory system of rendering account and in the sense of being accessible (Schnedler 1999). More generally, public accountability involves the means by which public agencies manage expectations within and external to their organizations (Romzek and Dubnik 2018) and willingness to take actions ranging from routine oversight to criminal sanctions in the event of unlawful actions or oversights by public officials or agencies (O'Donnell 1998). Whereas fairness in public administration ensures the same benefits and opportunities across the community, some approaches to justice acknowledge differences influenced by social and historical contingencies emphasizing the redistribution of resources to the least advantaged.

Box 10.1 Definitions of key terms

(1) Crowdsourced data refer to digital data sourced from a large group of people, including explicit sources of collaborative, user-generated mapping data and implicit sources such as social media data (Kitchin 2014; Crooks et al. 2015). The concept of crowdsourced data in this chapter refers to data both volunteered and contributed by individuals through networked digital devices. The term crowdsourced emphasizes the process of data collection, which refers to data sourced by the crowd. The term crowdsourcing refers to a bottom-up grassroots approach to contribute information (Crooks et al. 2015).

(2) Big data, according to the National Institute of Standards and Technology, "consists of extensive datasets—primarily in the characteristics of volume, variety, velocity, and/or variability—that require a scalable architecture for efficient storage, manipulation, and analysis" (Chang and Grady 2019). Crowdsourced data can be a source of big data. However, big data processing includes not only data collection but also the preparation, analytics, visualization, and access of data. Iglesias et al. (2020) note that big data processing includes data collection, validation, cleaning, standardization, reformatting, extracting information or knowledge from the data, presenting insights to the public optimally, and handling information requests of the public.

(3) Open data refers to digital data that is freely available, accessible, and usable by researchers, decision-makers, and the public. Open data can refer to the accessibility, sharing, and interconnectivity of data (Haeussler et al. 2014; Halevy et al. 2009). Li et al. (2019) provide a list of eight major open data disaster data sets including socio-economic, space, hydrological, meteorological, seismic, geographic, health, and disaster loss data. However, they find that locating and accessing relevant data for disaster events pose significant challenges for disaster researchers and public managers.

Below, we outline three categories of open government approaches in disaster planning, recovery, and response that rely primarily on mobile networks and other advanced digital technologies. Next, we analyze three representative case studies that exemplify the use of these approaches focusing on the opportunities and challenges they offer. Finally, we reflect on whether these initiatives improve public accountability and comment on the critical barriers and challenges to the use of advanced digital technologies in disaster management.

10.3 Leveraging Digital Technologies to Communicate and Interact with the Public

Disaster managers need to communicate with the public to issue alerts and warnings, gain situational awareness of an evolving disaster situation, educate the public about disaster preparedness and response, disseminate information, answer queries and provide feedback, and provide emotional support (Ahmed and Sargent 2014; Ahmed 2018). A significant body of work has found that Web 2.0 digital technologies like social media, blogs, and online forums are used by people during emergencies to exchange information, connect with others, and find support (e.g., Haverin and Zach 2010; Palen et al. 2007; Vieweg and Anderson 2010; Radianti et al. 2016). These same digital tools have been used by disaster agencies to coordinate disaster relief efforts, find missing persons, and provide shelter for victims (Kavanaugh et al. 2012; Ortiz and Ostertag 2014).

However, the pervasive use of these technologies has led to numerous new challenges, undermining the utility of the tools for open government goals, hindering response efforts, and jeopardizing the safety of community members and first responders. The rampant spread of inaccurate, misleading, and false information on these web platforms largely because of the design of the algorithms used by social media platforms is one of the most serious societal challenges facing us today (Zuboff 2019). These technologies can be used maliciously too intentionally to disrupt, confuse, or thwart disaster response (Gupta et al. 2013).

Further, the information and communication deluge and overload caused by digital technologies is linked to managerial stress, loss of agency and autonomy, and impedes decision-making quality. In addition to these psychological and cognitive costs, disaster response agencies incur administrative costs that are diverted from other needs. These costs include the personnel to monitor multiple social media, respond to the large volume of public questions, and verify the accuracy of incoming information (Misra et al. 2020a, b; Roberts et al. 2021).

Finally, there are numerous privacy concerns around the collection, retention, and data mining of personal information by disaster management and law enforcement agencies (Kavanaugh et al. 2012). In the United States, federal agencies are mandated to assess the privacy impact of any new or significantly updated technology system by the E-Government Act of 2002. In 2010, the Department of Homeland Security published a Privacy Impact Assessment on the Use of Social Networking Interactions and Applications to guide government use of social media. The assessment applies to government interaction with the public over social media, but it does not apply to online activities such as monitoring initiatives, law enforcement and intelligence activities, which are addressed through other initiatives (Bertot et al. 2012; DHS 2019).

10.4 Leveraging Crowdsourced Data for Improved Decision Making

While the Web 2.0 technologies described above facilitate large scale, multi-way communication, the next generation of technologies (sometimes called Web 3.0) allow for community-oriented computing, collective intelligence and distributed problem solving and have the potential to reshape how people participate in emergency management. Web 3.0 technologies have the potential to understand and categorize data, code data with similar characteristics, and retrieve crisis-specific data effectively and efficiently for agencies, business organizations and the public (Redman and Bruwer 2016)**.** One type of Web 3.0 technology is crowdsourcing data platforms. Crowdsourcing is the volunteer-generated, decentralized contribution of information online. Crowdsourcing data platforms can synthesize human intelligence at large and use either manual, individual human coding and data sharing or automated digitized approaches for efficient information processing and improved decision making.

In one prominent example, when Superstorm Sandy hit the East Coast of the United States in 2012, over 6000 volunteers analyzed more than 35,000 photographs. The crowdsourced analysis combined with several other geospatial technologies, accelerated FEMA's response operation by several days over previous methods. Superstorm Sandy saw the creation of several new grassroots technology organizations that now provide services to the government during crises which initially started as crowdsourcing initiatives. Some of these specialized tech startups analyze images and create maps for disaster planning and management. Others develop algorithms to search, select, translate, categorize, analyze, and summarize online information, including social media posts. Still, others collaborate with experts to develop and deploy tools from citizen scientists and technologists for disaster response (Crowley 2013).

Some scholars argue that automating the process of extracting relevant information from large volumes of online data can address some of the communication and information processing challenges inherent in Web 2.0 technologies for open governance and show promise for augmenting the capacity of federal, state, and local agencies (Ahmed 2018). Furthermore, passively harvesting crisis data from social media obviate problems of suboptimal user interfaces or crashing websites that can impede the use of purpose-built crowdsourcing applications (Harrison and Johnson 2016; Roberts and Doyle 2017a). Leveraging Open Data, Big Data, and Data Analytics for Intra- and Inter-Governmental Collaboration in Disaster Management.

Hurricane Katrina (2005) and Hurricane Sandy (2012) revealed that timely and efficient inter-governmental and intra-governmental communication as well as communication and information sharing across functional agencies play a critical role in effective response to disasters. Hurricane Katrina and to a lesser extent Hurricane Sandy highlighted the gaps in information sharing across levels of government and sectors that contributed to slower and uncoordinated response and insufficient deployment of resources (Chen et al. 2017).

A number of scholars have argued that open data and data analytics support better coordination and timely decision-making in emergency and crisis management (Olyazadeh et al. 2016; Balbo et al., 2013). In the context of disaster governance, the capacity to analyze massive amounts of data generated through mobile networks, apps, and sensors and turn it into reliable, trustworthy, and actionable information can aid the identification of vulnerable places, assets, populations and infrastructure facilities and aid decision making necessary to balance resource requirements.

OnTheMap for Emergency Management is a public web-based tool and interface for accessing U.S. population and workforce statistics, in real time, for areas affected by natural disasters. The tool integrates real-time data updates from the National Weather Service's (NWS) National Hurricane Center, Department of Interior (DOI), Department of Agriculture (DOA), FEMA, and social, economic, and housing data from the American Community Survey (ACS). This tool affords greater reporting flexibility to better analyze communities affected by disaster events because it generates reports for specific communities for regional, local, and comparative analyses and creates linkable maps and reports for easier sharing (Chen et al. 2017). While there is a substantial body of research on the leveraging of digital technologies on emergency response, there is comparatively less on digital and open government initiatives for disaster planning and preparedness.

10.5 Three Examples of Open Government Technologies for Managing Disasters in the United States

10.5.1 Background on the United States' Emergency Management System

The complexity of the U.S. structure leads open government technologies to be used to coordinate actors who may not communicate directly but share goals of preparing for, responding to, or recovering from disaster. The U.S.'s large size, diversity of regions, and multi-level system of government in which states are independent constitutional entities make coordination challenging, and purely top-down, centrally planned coordination impossible.

The U.S. disaster management system is "locally executed, state managed, and federally supported" according to the National Response Framework (DHS 2019, 5). The national level, referred to as the "federal" government provides strategic direction and operates programs to support hazard mitigation, disaster preparedness, and response. However, the federal government often works through states and localities by providing advice and grants-in-aid. The Federal Emergency Management Agency (FEMA) is part of the Department of Homeland Security and is a key disaster management agency. State governments, in turn, communicate federal policy to localities, create their own policy, and evaluate local hazard mitigation plans and grant applicants and provide support to localities (Smith et al. 2013). Local governments and

their police, fire, and city and county employees are the first responders after a disaster, and they make many of the most important decisions about reducing risk and mitigating hazards. Localities identify strategies to mitigate hazards, and they set rules regarding development, such as land use plans and building code enforcement.

10.5.2 Leveraging Digital Technologies to Communicate and Interact with the Public: The Use of NextDoor in Hurricane Recovery

The use of social media is one way in which emergency managers communicate with the public and sometimes each other before, during, and after disasters. Government emergency management offices now routinely make social media communications part of a larger communications strategy (Hughes and Palen 2012). Unlike older forms of "one to many" communication in which official communication flowed from a central government node to the public, social media is more diffuse, with many different nodes and connections (Misra et al. 2020a, b). Therefore, it can use public data formally as part of open government initiatives in new ways, or it can mix government communications with private ones. Social media technologies are part of governance and not just government since they connect public sector agencies, nonprofit organizations, private businesses, and individual residents, sometimes in response to an evolving disaster.

In one prominent example, after Hurricane Harvey struck Texas in 2017, social media applications were used to coordinate rescue operations and assistance to victims. The government issued calls for help, but the government did not coordinate assistance centrally. Instead, the public used social media applications including NextDoor to coordinate assistance. The NextDoor application defines membership according to user-defined geographically proximate areas called neighborhoods.

One study found that among 333 NextDoor Neighborhoods in the Houston, Texas area, activity on the social media application was associated with higher rates of rebuilding after Hurricane Harvey at a statistically significant level (Page-Tan 2021a, b). In this study, people who used NextDoor were more likely to receive help from friends and neighbors than people who never used the social media application—a finding not replicated with the use of other social media accounts, including Twitter and Facebook.

After Hurricane Harvey, many individuals reported that social media applications provided locally relevant and actionable information for people who wanted to provide assistance. One person interviewed for a study on social media use during the hurricane explained the relevance of social media compared to broadcast news by saying, "If you're just at home watching the news …they're just—it's just the drastic stuff, you know? And it's not really right there in your neighborhood" (Smith et al. 2021, p. 122). Social media sites connected people who needed assistance with

people who could offer it, as well as with people who could identify needs on behalf of others.

The use of social media sometimes blurs the lines between official and unofficial roles. One government employee who responded to Hurricane Harvey said, "I'd see somebody post on Facebook 'Oh, I want to go to Starbucks.' I think I told a couple of friends, 'No, don't because there's water at such and such'…I couldn't respond as an official department member, but as myself" (Smith et al. 2021, p. 123).

At the organizational level, social media can blur the distinction between official government information and information from private and unofficial sources. The blurring of the sources of information contributes to problems of rumor, misinformation (incorrect) or disinformation (deliberately misleading) (Wang & Zhuang 2018). Many emergency management offices mitigate the spread of rumor and misinformation by establishing official social media channels and publicly countering rumors with correct information and explanations (DHS 2019).

Social media use in the aggregate may be associated with faster rebuilding, but using social media effectively depends on a number of factors in place before disasters occur. Effective use requires telecommunications infrastructure, pre-existing social and material capital, and a willingness to define social media groups or neighborhoods in the case of NextDoor to include people in need (Page-Tan 2021a, b; Payne 2017).

Successful crowdsourcing via social media requires skilled "digital volunteers" who can connect those in need with those who have resources to offer (Smith et al. 2021, 116). Digital volunteers possess a range of skills, including the ability to do localized reporting, educate others, and engage in logistical tasks to dispatch aid (Smith et al. 2021, 125). Like official sources, digital volunteers also need to cultivate trust in order to provide assistance.

10.5.3 Leveraging Crowdsourced Data for Improved Decision Making: Damage Assessment After Hurricane Sandy

Disaster management in the digital age is characterized by the risk of information overload, and a key challenge for practitioners is converting a torrent of information into situational awareness and useful on-the-ground knowledge in a timely fashion (Misra et al. 2020b). Liu (2014) discusses crowdsourced processes of tagging, mapping, and curating data, distilling raw data into "actionable crisis information" for emergency managers (p. 409). Crowdsourcing initiatives utilize large numbers of geographically dispersed volunteers and divide major projects into smaller discrete tasks. Crowley (2013) describes their major contribution as "accelerating sense making during emergency operations" (p. 59).

The first large-scale utilization of crowdsourcing by a U.S. disaster management agency occurred in 2012, after Hurricane Sandy struck the northeastern coast. Utilizing aerial photography by the Civil Air Patrol (CAP), which can rapidly reconnoiter affected areas, FEMA partnered with Humanitarian OpenStreetMap

(HotOSM) volunteers to develop a digital platform and workflow process to quickly analyze the tens of thousands of images collected. HotOSM volunteers used a modified version of MapMill, originally developed by the Public Laboratory for Open Technology and Science (PLOTS), another non-governmental organization, making CAP images available for crowdsourced analysis. Several thousand volunteers conducted over 137,000 assessments of over 35,000 aerial photographs, categorizing them according to the perceived level of property damage: light, moderate, or heavy. Most of this work was completed over two days, giving FEMA a detailed picture of where federal assistance was most needed (Crowley 2013; FEMA 2013; Becker and Bendett 2015; Roberts and Doyle 2017a).

The potential for crowdsourced mapping to aid disaster response was apparent by early 2010. After a devastating earthquake struck Haiti, HotOSM volunteers were able to accomplish over a year's worth of cartographic work in 2 weeks, providing instrumental local knowledge to international response teams (Becker and Bendett 2015). The same year, however, when an explosion on the Deepwater Horizon precipitated the worst oil spill in U.S. history, crowdsourced damage assessment was carried out in spite of, rather than in collaboration with, official disaster response agencies.

Warren (2010, p. 71) notes the "close collaboration between BP, the Coast Guard, and NOAA" in limiting journalists' documentation of the affected coastline during the spill. In response to this information blackout, Gulf Coast residents developed a low-tech method to photograph oil spill damage, attaching digital cameras to weather balloons. PLOTS emerged from these community-driven efforts; the original MapMill platform was developed to compile the images collected. In this case, a key advantage of crowdsourcing may have been its decentralization and its utilization of readily available low-tech tools, allowing documentation of coastal damage to proceed in spite of official opacity.

A number of specific legal and policy challenges arise at the interface between public disaster management agencies and grassroots crowdsourcing organizations, the former characterized by defined bureaucratic procedure and legal constraints and the latter by more fluid organizational structures. These challenges can lead to tensions in partnerships between government agencies and grassroot organizations. Challenges include: strict data-quality standards; prohibition on publishing personally identifiable information; and restrictions on the dissemination of protected datasets generated by the public sector or licensed datasets generated by the private sector (Crowley 2013; Liu 2014; Harrison and Johnson 2016).

The development of government-grassroots interfacing procedures can be an iterative process, which takes time to operationalize. For example, months before Hurricane Sandy made landfall, FEMA and the National Geospatial-Intelligence Agency conducted exercises disseminating CAP images to HotOSM volunteers for analysis using the MapMill platform, prefiguring the crowdsourcing response employed successfully after the storm (Becker and Bendett 2015). This critical preliminary work likely contributed to their successful use during the disaster.

To effectively utilize crowdsourcing, disaster management practitioners must: anticipate situations in which its application would be advantageous; identify and

ameliorate policy constraints on grassroots-government cooperation; and proactively cultivate relationships with suitable grassroots crowdsourcing organizations (Crowley 2013). While crowdsourcing itself is most often associated with disaster response, the necessity of proactive planning means it should be considered in the mitigation realm as well.

10.5.4 Leveraging Open Data, Big Data, and Data Analytics for Intra- and Inter-Governmental Collaboration in Disaster Management: The Hazus Risk Estimation Program

One of the most long-standing FEMA efforts at risk communication and transparency to improve collaboration is the Hazus program. FEMA first released this free, publicly available GIS-based software in 1997. It has been updated several times and it is used by state and local emergency managers to "estimate potential damage, economic loss, and social impacts from earthquake, flood, tsunami and hurricane wind hazards" (FEMA 2018). The software provides states and localities with tools to estimate risk in their area, which they can use in hazard mitigation and development plans. It includes a database of geographic features and buildings, damage models for various hazards including flood, earthquake, and hurricanes, economic loss models, and building damage models (Schneider and Schauer 2006). It has been widely used by states and localities in their planning, and Natural Resources Canada worked with FEMA to develop a Canadian version of the tool for estimating potential losses from natural hazards (Nastev and Todorov 2013).

The wide adoption by hazard planners as well as scholars is an indicator of the effectiveness of the program. Having a standardized model that is freely available allows communities to compare their losses with other communities, and scholars can use the database to make relative assessments across the UnitedStates. Like many models, however, its predictions are only as good as the data inputs, and in many cases, the standardized inputs are not accurate (Schultz 2021). Given the size and changing hazards profile of the UnitedStates, communities need to provide their own more accurate and updated data in order to generate accurate predictions, but often communities do not do so. The result is inaccurate predictions.

For example, damage to building structures is almost always the largest part of disaster damage in the United States (NOAA 2021; Shultz 2021). However, one study found that the Hazus general building stock data set led to an exaggeration of building replacement costs by 86% and depreciated costs by 165% when compared with more accurate local building data from Harris County, Texas (Shultz 2021).

The lesson is that users of the open government tool need to input their own updated data in order to derive the greatest benefit from the tool. Hazus is not a "wonder drug, one that would enable a jurisdiction to 'drop in' case scenario data and get immediate and accurate risk assessments and results" (Beckmann and Simpson

2006, p. 40). Instead, it is a tool for state and local governments and others who want to estimate disaster risk. Governments and nonprofit and private sector users need to consider how they will acquire data to input into the software, as well as the cost of data acquisition. Some reviews have suggested that potential users should consider alternate tools to estimate damage if the cost of acquiring accurate data and using Hazus is too great (Beckmann and Simpson 2006). Hazus provides an example of how government agencies and planners can use open data to reduce risk while also showing the limits of such programs in a dispersed system.

10.6 Conclusions

Open government initiatives in the United States are poised to grow in the disaster management realm. While these initiatives began as a public management reform effort, they have gathered momentum with the development of new technologies, the proliferation of data, and storage space through computer hard drives and internet cloud-based services. In the United States, recent efforts at evidence-based practices at all levels of government take advantage of open government data as public officials seek evidence for policy decisions and practices (GAO 2021).

In the disaster management realm, open government has been used to improve disaster preparedness, inform mitigation decisions, hasten response and foster collaboration across organizational and sectoral boundaries. The three cases analyzed in Table 10.1 show that both official government open data programs such as Hazus and bottom-up efforts such as the use of NextDoor after a hurricane can connect people in need with those who are able to help and empower people to take action before, during, or after a disaster. Opportunities for action may be planning decisions to reduce risk before a disaster occurs, or the opportunity to deliver assistance during a rapidly unfolding event.

Both formal and informal open government initiatives have been less successful at delivering on the promise of public accountability, and ultimately fairness and justice. All three illustrative cases show the value of open data initiatives and the sharing of data between government and non-government actors, and across government agencies. However, these initiatives have not automatically led to greater government accountability. The process of accountability often occurs after a disaster when people ask what went wrong, investigate the causes, and seek remedies. Sometimes post-disaster action reports bring to light government shortfalls, but other times official reports neglect laying blame (Knox 2013). In either case, they require someone to take action to remedy a perceived shortfall.

The use of public funds is a central concern of open government as a public management reform. However, the money spent on recovery after major disasters is often not part of these open government initiatives and is difficult to find. After Hurricane Maria devastated the Caribbean in 2017, including the U.S. territory of Puerto Rico, the U.S. government allocated tens of billions of dollars in aid. However, much of the money was not spent initially because of supply chain issues and the

Table 10.1 Comparison of Illustrative cases on open government in disaster management

Illustrative case	NextDoor in Hurricane Harvey	Hurricane sandy	Hazus
Approaches to open government	Digital technologies to communicate and interact with the public	Crowdsourced data for improved decision making	Open data, big data, and data analytics for intra- and inter-governmental collaboration
Opportunities for transparency and improved outcomes	• Connects providers of assistance with actionable information • Communication occurs more quickly and through more nodes than is possible through official channels • Social media is usually visible, though there are limits to government's ability to monitor, evaluate, and collect data from social media	• Distills data into actionable information for emergency managers and government	• Potential for state and local governments and other users to estimate disaster risk and then reduce risk
Contribution to public accountability	• Involves public in the coordination and provision of disaster aid	• Makes new data visible and actionable to show where assistance is needed • Potential for evaluation of government performance relative to needs afterwards	• Makes disaster risk visible • Potential to hold governments accountable for not taking action to address identified risks
Challenges	• Blurs the lines between official and unofficial roles • Potential for rumor and misinformation • Depends on pre-existing factors including telecommunications infrastructure and digital volunteer skills	• Government standards for data quality and protection may not match grassroots practices for openness and sharing • Potential for rumor and misinformation • Requires infrastructure and practice before disaster occurs	• Users need to acquire and input their own updated data for the greatest benefit • Acquisition and inputting of data can be costly

requirements needed to document spending from national government aid programs. A nonprofit organization used publicly available data to criticize the government for moving slowly in spending the money, but the data were not easy to find or interpret (Honl-Steunkel 2020). A Puerto Rico government initiative established a website to track spending and recovery progress, and the website remains in use as of January 2022 (COR 3, 2022). Efforts to hold the government accountable for appropriate disaster spending may rely on a mix of NGO advocacy and pressure, and government initiatives to share data specifically for accountability.

Future open government initiatives in disasters may learn by addressing the challenges outlined in Table 10.1. Large open government initiatives require investment in data acquisition and input into a system to share data. Rather than simply putting new data on the public Internet, open government could include a comprehensive initiative to adopt methods and protocols that help officials interpret incoming information and help to eliminate or reduce misinformation.

The cases show that open government is a process rather than a single act or state of being. Even the seemingly improvised bottom-up initiatives rely on critical antecedents that are put in place before disaster occurs, including infrastructure and response exercises. The NextDoor app relies on pre-defined neighborhood zones and an established user base. Crowd-sourced data sharing in Hurricane Sandy relies on exercises before the event between government and non-governmental groups. Finally, the Hazus database depends on data being updated, and steps in which the data are communicated to the public, often through local government hazard mitigation plans. Future open government initiatives may benefit from specifying the purpose of the initiative and adopting a theory of change that identifies how the initiative is intended to bring about particular outcomes. Such a theory of change for open government in disaster management should identify the key antecedents, inputs, and intervening contextual factors, including the human, technological, and organizational factors, required for particular outcomes. Those outcomes may include the original public management reform purpose behind open government: holding the government accountable for the actions it takes on behalf of the public.

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Chapter 11
Technology Landscape in Post COVID-19 Era: Example from China

Jinling Hua and Rajib Shaw

Abstract COVID-19 has deep impacts on the already pressed world, where the existing vulnerabilities due to human and climate induced risks were prominent. However, the pandemic also provided ample opportunities for innovation and technology development. It is often said that the last 12 years of innovation is done in the last 2 years. China is no exception to that. With an already high investment in technology development, COVID-19 also urged China to reshape its new and emerging technology regimes through appropriate governance mechanisms, and innovation in technology development. This chapter will cover some of these technology developments as well as its governance mechanism to develop a technology and innovation ecosystem in post COVID-19 context in China.

Keywords Post COVID-19 · Technology landscape · China · Innovation · Community functions

11.1 Introduction

In December 2019, a new coronavirus infection, later named COVID-19 by the WHO, emerged from Wuhan City in Hubei Province. As the infection exploded, the Chinese government implemented a lockdown of Wuhan City and Hubei Province starting January 23, 2020, to prevent the spread of the disease. As a result, large-scale lockdowns were implemented in Wuhan City, with a population of over 10 million, and Hubei Province, with a population of approximately 60 million. A total of about 700 million Chinese were subsequently restricted in their activities.

At the peak of the outbreak in Wuhan City on February 12, 2020, the number of newly infected people was 15,152 (Fig. 11.1, Sina News 2021). Between January 24 and March 8, 346 physician support teams, 42,600 medical personnel, 900 public

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health experts, and 4,000 People's Liberation Army doctors were dispatched from all over the country to Wuhan (China State Council Press Office 2020). As a result of a series of hard-line measures, the number of new infections dropped to triple digits (396) on February 19 (Sina News 2021). After March 7, the number of infections per day dropped to double digits, Xi Jinping inspected Wuhan on March 10, and the airport, subway, and other public transportation in Wuhan resumed operations on March 23. On April 8, the 76-day-long blockade of the city was lifted in its entirety.

As of August 31, 2021, the number of newly infected people nationwide was 19 (Sina News 2021), but a localized lockdown is in place. The number of people infected with the new coronavirus in China so far is 94,898, 89,240 cured, and 4,636 dead (National Health Commission of the People's Republic of China 2021). Although the lockdown that has been implemented so far is a classic method of infectious disease control, it is unique in China in that it uniquely combines a robust countermeasure system, full use of information technology, thorough countermeasures in a community-based base organization, and close communication with residents. The Chinese model of countermeasures against new coronavirus infections is being formed.

The purpose of this paper is to elucidate concretely how the Chinese government is confronting COVID-19, who is taking measures and how, and how it is using information technology. In the modern age, the development of information technology and its penetration into society has led to a great advance in advanced information technology. We will attempt to clarify the use of information technology in COVID-19, the actual state of social control using information technology, what kind of national will is involved, and how it is working through the COVID-19 response.

11.2 Background of China's COVID-19 Response

11.2.1 Fighting the Virus in Wuhan City

Hua and Shaw (2020) organized people's actions from December 1, 2019, to the end of February 2020 regarding the initial response to fight against the virus and corona, especially in Wuhan City. In addition to strong governance, strict regulations, close vigilance, and the use of big data and new technologies, starting with the January 23 urban blockade of Wuhan, there has also been a significant increase in the number of people infected. Since March, the number of newly infected people has been controlled to two or three digits (Fig. 11.1), and the focus of corona control has shifted to fighting imported infections from abroad.

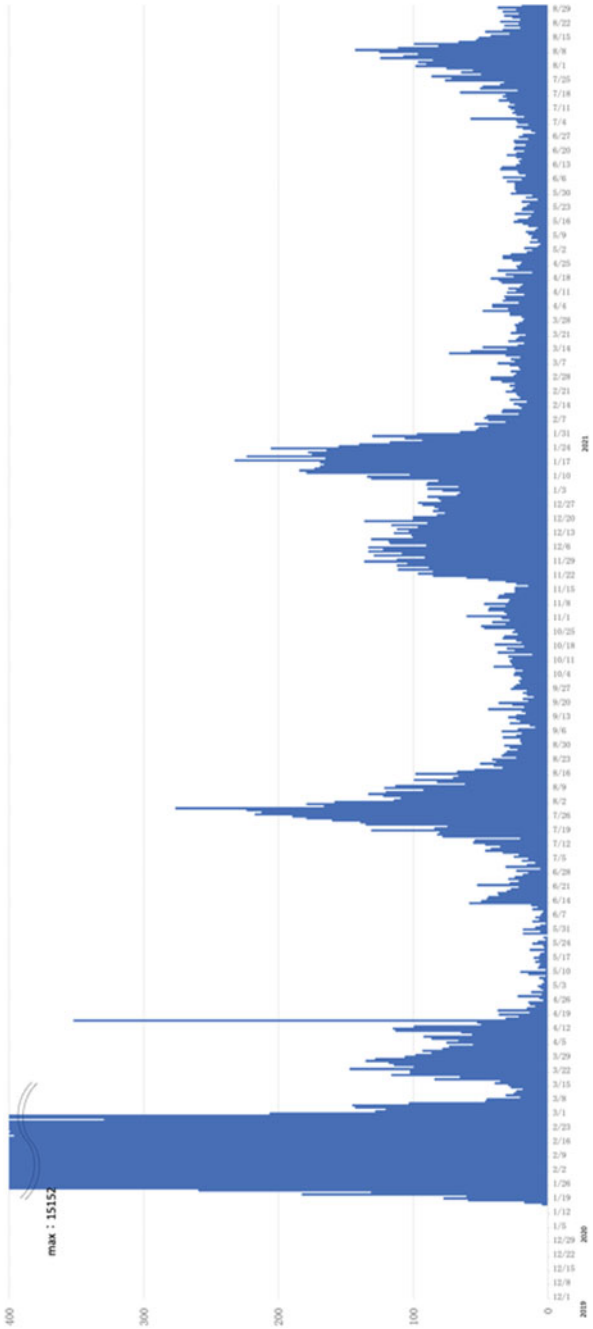

Fig. 11.1 Number of newly infected COVID-19 patients. *Source* This figure was prepared by the Authors using original data from Sina News (2021)

11.2.2 Information Concealment and Initial Response by Local Governments

In this section, we point out that although China's coronary control measures lagged behind in the initial response, it is in this failure that important elements are hidden that will lead to later measures. On December 30, 2019, the Wuhan Health and Sanitation Commission promulgated an emergency notice on pneumonia of unknown origin. The following day, on the 31st, the National Health and Sanitation Commission, which was aware of the information, sent the first team of experts to Wuhan (CCTV 2019). However, it was not until after the third expert team's investigation on January 20, 2020, that it was officially announced that the new pneumonia was "human-to-human". In fact, by the time the first team of experts arrived in Wuhan (in the morning of December 31, 2019), it had already been confirmed that it was the "SARS virus" and that it was "infecting people" at the Wuhan Central Hospital. However, there was a move to conceal the information.

Two grounds can be cited in support of this: one was the summoning of Li Wenliang (an ophthalmologist at the Wuhan City Central Medical Hospital) to the Wuhan Health and Safety Commission from 1:30 to 4:00 in the early morning of December 31, and the compulsory submission of a written reflection on "spreading false information" (Caixin 2020). Li Wenliang was the one who later became known as "the one who sounded the alarm of the new pneumonia" when he forwarded to a WeChat group of doctors an image of an examination report shared by Dr. Ai Fen, also of the Emergency Department of Wuhan City Central Medical Hospital, on December 30. On December 29, Ai Fen examined four patients with fever in the emergency department, two of whom were infected from mother to child. Since the mother had been infected simply by delivering a lunch box to her son, who worked at the South China Seafood Market, Ai Fen determined that the infection was "person-to-person" and immediately reported it to the hospital's public health department. The next day, on the 30th, Ai Fen received a CT image report of an outpatient who had been brought to the emergency room on the 27th of the same month, which showed "SARS coronavirus". Since several patients with the same symptoms had been confirmed every day, Ai Fen marked the area in red and contacted the hospital, as well as alerting her colleagues via WeChat (China News Weekly 2020). Li Wenliang, who was warned by Ai Fen, forwarded the red circled "SARS coronavirus" image to the WeChat group of his colleagues.

The second reason is that on January 1, a direct order from the Hubei Provincial Health Commission was sent to the inspectors of the DNA sequencing company BGI: "Do not report any similar samples found in Wuhan, destroy all existing samples, and do not leak any information about the samples or quote data. At this point, the company was in the Wuhan area. At this point, the company had already identified three SARS-like samples from Wuhan hospitals (December 26, 29 and 30).

The first team of experts dispatched by the National Health Commission arrived in the morning of December 31, and at 1:00 p.m., before they had time to investigate, the Wuhan Health Commission issued the first "Wuhan City Pneumonia Situation

Notice". The notice stated, "There are 27 cases of infection, 7 of which are serious cases, and all patients are being treated in isolation, no human infections have been confirmed, and no medical personnel have been infected. The causes and sources of infection are under investigation".

On January 1, a 65-year-old male doctor who runs a clinic near the South China Seafood Market was brought to the emergency department to which Ai Fen belongs with a fever. The doctor had seen many patients with fever from the South China Seafood Market and was suffering from the exact same symptoms as those patients. Therefore, Ai Fen was convinced that it was a "person-to-person" virus. She immediately reported to the hospital's public health department and the hospital's general affairs department that the virus had infected people and had begun to infect medical personnel, but after receiving no response from the hospital, she returned to the emergency department and instructed the emergency department to immediately wear N95 masks (China News Weekly 2020).

However, on the same night, a notice from the Wuhan City Health and Safety Commission was sent to the doctors at the central hospital. The content of the notice was, "To avoid panic, information about pneumonia of unknown cause must not be released to the outside world without permission. In the middle of the night, she received a call from the hospital's monitoring department, and when she went to the hospital the next day, she repeatedly told them that the disease was spreading from person-to-person on a certain scale. When she returned to the emergency department, she alerted her 200 or so subordinates and doctors to take precautions against infection, and again asked them not to spread the information to their families.

On January 1, the official Weibo of the Wuhan Municipal Public Security Bureau, "Ping an Wuhan," announced that it would investigate and punish the eight Wuhan citizens who had spread the hoax, and on January 3, eight doctors, including Li Wenliang and Ai Fen, were reprimanded for spreading the hoax. On the other hand, on January 2, the hospital began to prohibit any kind of written or visual record of the pneumonia of unknown origin, and the doctors in charge of examinations were instructed to hand over the patient's condition only orally when they took turns.

11.2.3 Causes of Infection Explosion in Wuhan City

On January 5, the Wuhan Health and Safety Commission promulgated the No. 3 notice, "59 cases of infection, no human infection confirmed, possibility of SARS eliminated". China Central Television reprinted the notice in full, emphasizing that "Wuhan unknown pneumonia has been ruled out as a possible pathogen caused by SARS. On January 9, Central Television reported that the pneumonia in Wuhan was caused by a new coronavirus and that the gene sequence of the virus had been analyzed. On January 10, the second expert team (January 8–15) was established. On January 10, Wang Guangfa, head of the Department of Respiratory and Critical Care Medicine at the First Medical School of Peking University, who was a member of

the second expert team (in Wuhan from January 8–15), announced that the infection was under control (China Youth Daily 2020).

In response to the Wuhan Health and Safety Commission's No. 3 notice and a series of national media reports, the third meeting of the 13th Wuhan Municipal Committee of the Political Consultative Conference was held in Wuhan until January 8, and the fourth meeting of the 13th Wuhan Municipal Committee of the Political Consultative Conference was held from January 7 to January 10, the Hunan Provincial People's Congress was held from January 12 to 17, and on January 18, a large banquet of 40,000 people, the "Hundred Steps Pavilion On January 18, a large banquet, the "Hundred Steps Pavilion All House Banquet," was held with 40,000 people in attendance. Such a tense situation lasted until just before the press conference after the third team of experts led by Dr. Zhong Nanshan, who is considered to be the top doctor in China for infectious diseases, returned to Tokyo, and the situation changed drastically. In view of the later infection data, the infection explosion in Wuhan City may have been spread by this series of meetings (Fig. 11.1).

On January 20, Zhong Nanshan declared in an interview with Central Television that "person-to-person transmission has already started, and medical personnel have also been infected" (CCTV 2020). In other words, it took 20 days for China to finally grasp the seriousness of the spread of the new pneumonia infection by dispatching expert investigation teams three times in total, but it must be said that the precious timing for treatment in Wuhan was lost. The fact that a team of experts was immediately dispatched by the central government in response to the emergency notice from the Wuhan Health and Welfare Commission on December 31 can be evaluated as a swift response by China. However, the Wuhan Health and Safety Commission and the local government, which are supposed to "avoid panic," paid a heavy price for their lack of awareness and concealment of information about the new pneumonia. However, TV reports and later newspaper articles on January 9 loosened people's tension. Data on the flow of people from Wuhan also supports this (Marukawa 2020a:79, 2020c, 2021:4). In view of this history, Marukawa points out that the spread of the infection in Wuhan was caused by the misjudgment of some scientists and the overconfidence of politicians and people in the power of science (Marukawa 2021:3–4).

Based on the above information concealment, we believe that the fundamental cause of the infection explosion in Wuhan City lies in the way information is communicated from the medical frontline to the central leadership. In other words, the problem lies in the fact that valuable primary information, which was available only at the medical front, was not shared with the central leadership. On January 10, Wang Guangfa announced that the infection was under control. According to an interview with Wang Guangfa, who was discharged from the hospital on January 30, "The clinical symptoms of the patients in Wuhan were very close to SARS, but our team of experts was in a state of confusion about 'person-to-person transmission' all the time. We were always very vigilant, but we had very little information at hand and no scientific evidence that it could be transmitted from person-to-person" (China Youth Daily 2020).

Ironically, only the local government's distorted award and punishment of the first discoverers was swift, while the local medical field failed to disclose information and respond appropriately. This inappropriate and arbitrary response by the local government, and the reflection on the failure to accurately collect and share information from the medical field, may have led to the later development of China's corona control system and the thorough introduction of information technology.

11.3 Initial Response of the Central Government to COVID-19 Response System

11.3.1 Central Government's Initial Response

On January 20, the day of the "human infection" by Zhong Nanshan, Xi Jinping issued "important instructions" on infection prevention, and in response, Li Keqiang held a meeting of the Standing Conference of the State Council to take various measures against the new pneumonia (People's Daily 2020a; Xinhua News 2020). At this meeting, it was decided that the new pneumonia, which was previously classified as Class B in the Law of the People's Republic of China on the Prevention of Infectious Diseases, would be treated as Class A, which would allow movement restrictions in infected areas (National Health and Safety Commission 2020a). As a result of this change, local governments and medical institutions can now legally take measures to restrict movement and quarantine. The number of infected people by this date was 258 (News 2021).

At the same time, a series of emergency response groups, including the State Council, began to form. after the Standing Conference of the State Council held by Li Keqiang on January 20, a "Joint Countermeasures Task Force" was set up within the State Council, led by members of the National Health and Welfare Commission. The members come from 32 departments and are divided into work teams for epidemics, medicine, science, diplomacy, and material security. The team leader is the head of the relevant department, and the team takes the form of a multi-departmental collaboration. On January 23, the Wuhan City New Pneumonia Countermeasure Command was organized, and on January 24, the Central Military Commission New Pneumonia Countermeasure Sub-group was established as a coordinating body from the Central Military Commission, and a total of 450 medical personnel from Shanghai, Chongqing, and Xi'an flew to Wuhan by military plane. On January 25, the Standing Committee of the Central Politburo established the "Central Pneumonia Control Guidance Subgroup" headed by Li Keqiang as a temporary Party organization to oversee the entire response.

11.3.2 COVID-19 Measures of the Central New Pneumonia Control Guidance Subgroup

The Central Sub-group for the Guidance of New Pneumonia Control became the supreme command center of China's corona control measures, and thoroughly discussed and directed corona control measures in Wuhan, Hubei and the rest of the country. The infection control measures taken by this sub-group can be divided into three categories: early, middle, and late, depending on the content of the response.

(i) Initial response (1/26–2/5)

In the early stages, a series of priority measures were taken, including the provision of supplies to Wuhan, dispatch of medical personnel, dispersal of patients with fever, acceptance of patients with severe illnesses, strengthening of measures in the community, accurate and timely updating of infection information, etc. Intensive care facilities such as Huoshenshan Hospital and Leishenshan Hospital were added.

(ii) Mid-term response (2/6–3/1)

After the sixth meeting on February 6, the Corona measures entered the mid-term stage. This was marked by the resumption of operations and the employment issue. The setting of this agenda is the most important aspect of the medium-term measures.

The February 6 meeting stated that in order to guarantee countermeasures against the spread of infectious diseases, it is necessary to restore normal production activities and achieve the maintenance of normal social order. On February 10, Xi Jinping expressed concern about the impact on economic activity and stressed the need to resume economic activity and solve the employment problem (People's Daily 2020c). On February 11, a meeting of the Standing Committee of the Central Political Bureau discussed the resumption of operations as well as measures to combat corona, and an article entitled "Let's Strive for the Two Victories of Preventing the Spread of Infectious Diseases and Achieving the Goal of Economic and Social Development" was published (People's Daily 2020d). On March 18, the State Council Office issued the "Implementing Opinions on the Impact of the New Pneumonia and the Realization of Stable Employment" and on April 7 the "Guiding Opinions on Effective Quarantine and Proactive Efforts to Resume Operations". the State Council Office issued the "Guiding Opinions on Effective Quarantine and Active Resumption of Operations" and the State Council Joint Measures Work Agency issued the "Guidelines for Resuming Operations of Enterprises in Different Risk Areas".

The issue of resumption of operations and employment was further concretized in the government activity report of the National People's Congress, which was later summarized as the economic policy goals for 2020 in "Liubaoliuwen". Liubaoliuwen" is a phrase that sets the tone for economic policy in

2020: "Six Stabilizations" and "Six Guarantees," both of which begin with the recovery of employment (Marukawa 2020a:86).

(iii) Later response (3/2–3/26)

The contents of the late measures included strengthening the contents of the work of the National Social District in anticipation of a prolonged period of corona control, and guaranteeing the livelihood of needy people and ambulatory personnel. In this period, the focus was on strengthening domestic and international measures to prevent the spread of infection.

11.3.3 Formation of a National System for COVID-19 Response

In late January 2020, the "Party Central Corona Countermeasures Command" was formed from the State Council Joint Countermeasures Work Organization. Since then, commanding departments of provinces, autonomous regions, and municipalities directly under the State Council have been established, as well as commanding departments of cities, districts, and highways (counties, townships, and villages in rural areas) under them.

11.4 Institutionalizing the "Community" Function

11.4.1 Institutionalization of Community Management

There are five legal bases for corona control in China: (1) "Emergency Regulations of the People's Republic of China on Sudden Public Health Incidents", (2) "Law of the People's Republic of China on the Control of Infectious Diseases", (3) "Criminal Law of the People's Republic of China", (4) "Law of the People's Republic of China on the Management and Punishment of Public Security", and (5) "Notice of the Supreme People's Court, the Supreme People's Procuratorate, the Ministry of Public Security, and the Ministry of Justice on the Involvement of the Supreme People's Court in the Obstruction of the Lawful Conquest and Control of the New Coronary Infection Pneumonia Epidemic". The first and second are the regulations on the responsibilities of the government, health departments, state organs, etc., and the third to fifth are the laws on the measures to be taken when medical personnel, epidemic control personnel and related personnel obstruct epidemic control work.

The first national instruction on community management for COVID-19 measures was the "Notice on Community Management Contents for COVID-19 Measures" (CCDC 2020) issued by the CCDC to all commanding departments nationwide on January 26. In particular, it instructs that the community should be gridded, the health of residents should be supervised, the movement history of residents should

be thoroughly monitored, and big data should be fully utilized to track the flow of people from Wuhan to their locations. It also includes the implementation of gridded management and comprehensive management, an organizational structure for the development of community COVID-19 countermeasure work, a work structure with full-time and part-time staff, the division of responsibilities among individual staff, ensuring communication with all households, thorough implementation of all community work, and encouraging community residents to participate in the management of preventive measures. The following are included in this report.

More detailed instructions on community work are provided in the "Wuhan City COVID-19 Commanding Department Notice" (No. 7 and 8) issued on January 24. In order to solve the problem of waiting time for hospital patients and pressure on hospital beds, it was decided that citizens with fever would be treated according to their symptoms. The community was to play a coordinating role. According to Notification No. 7, the community will check the status of fever patients in the district under its jurisdiction and respond to them according to the degree of fever. Other patients without fever will be kept at home, and their body temperature and daily life will be managed by the community (Wuhan Circulars No. 7 and 8).

11.4.2 Institutionalization of Community Housing Blockade and Personnel Structure

On February 6, regulations were also promulgated on the management of the blockade of residential areas under lockdown by communities. The Hubei Province Corona Countermeasure Command promulgated the "Notice on the Community's Management of Housing Zone Blockade". It detailed the community's organizational structure, the positioning of Party organizations, and the management of residents' lives. It stipulated that Party members should cooperate with their own communities, that the police and medical personnel should play a central role in the countermeasures, and that local social organizations and professional organizations, condominium management companies, supply companies, and volunteers should cooperate in the fight against corruption. Locking down residential areas and controlling access to them, managing the health of residents, disclosing infection information, disinfecting, and providing services for people with living difficulties were also supposed to be part of the community's job description (Hubei Province Command 2020). This provision was later reflected throughout the country as the basic model for community management in areas where lockdowns were implemented.

11.5 Institutionalizing Use of Information Technology in COVID-19 response

According to the Strategic Planning Framework for the Development of Emergency Management Informatization (2018–2022), China will complete the four major informatization development plans of sensing network, emergency communication network, big data system and business application system within four years from 2018. The emergency communication network is the emergency communication network composed of the command information communication network, satellite communication network, wireless communication network, national e-government network, national e-government internal network, and the Internet (China Emergency Management Department 2019).

This corona outbreak has challenged not only China's public health system, but also the government and corporate crisis management system. The enormous task of rapid information disclosure, tracing infected clusters, and investigating the route of infection resulted in the realization of a digitized social governance system that integrates the public and private sectors. The social implementation of many information technologies, such as big data, AI, 5G-enabled mobile PCR inspection buses, delivery of disaster supplies by self-driving cars to infected areas, and the emergence of various robots, has made significant progress; new infrastructure has been in place since March 2020, and the digitalization of society is in full swing (Hua et al. 2021). Big data and health codes, in particular, have been widely used for coronary control. Big data is mainly used to generate human flow data and human flow maps, while health codes are used to manage national movement restrictions.

11.5.1 Infection Cluster Discovery Using Big Data

(i) Human Flow Tracking and Precautionary Measures in Wuhan City

On January 26, at a Hubei Provincial People's Government newspaper press conference, Wuhan City Mayor Zhou Xianwang announced that about 5 million people had left Wuhan just before the lockdown (Economic Observer 2020). There was a discussion in the leadership sub-group about why and how these 5 million people left Wuhan, and it was decided to conduct a follow-up survey using big data to prevent the spread of infection (He et al. 2021a). At this time, there were three main methods of data collection and information disclosure used by the sub-group. The first was the use of government databases through the Wuhan City Corona Control Command and the use of databases of telecommunication and platform companies (He et al. 2021b). The second is the public release of an intensive contactor self-identification tool based on the collected and harmonized database (National Political Service Platform). This tool enabled the public use of big data, allowing anyone to check whether an infected person is present on the route they traveled by simply entering their ID

number. Third, open data, including information on infected people, was made widely available to the general public through the social media WeChat, Alipay, and Baidu maps.

Analysis and analysis of the big data were also underway. After the big data was harmonized and the team of medical experts convened arrived in Wuhan, a small group of leaders tracked the flow of people out of Wuhan based on train and airplane boarding data, cell phone location data of telecommunication companies, and the human flow database of Baidu map. According to the results, 60 to 70% of the people who flowed out from January 10 to January 22 stayed within Hubei Province, so they strengthened the management of the regions within the province and took preliminary measures in anticipation of the infection explosion in Huangshi and Ezhou cities. The data on the flow of people who had moved outside Hubei Province was shared with the local government to find out where they were. All of this work was completed on February 6 (He et al. 2021a).

At the same time, there was a case that triggered the leadership sub-group to pursue public–private social governance: during the visit to all households in Wuhan City (Hua and Shaw 2020) that started on February 4, the Wuhan Municipal State-owned Electric Power Grid Company provided electricity usage data and conducted a detailed analysis of all residents in Baibuting community and other important social zones. The detailed analysis of all residents in the Baibuting community and other important social areas contributed greatly to the countermeasures (He et al. 2021a). Since then, the guiding sub-groups have stepped up their calls to society, and more strongly recommended data sharing and business collaboration between provincial and local governments and enterprises, and between local governments and local leader enterprises.

(ii) Human Flow Tracking and Precautionary Measures in Wuhan City

On June 11, 2020, the first new case of infection in 56 days was reported in Beijing. As a result of tracing all the movement and mobile payment history data of all the infected people, the Xinfaji Food Wholesale Market was found to be the source of the infection. However, there were 4,000 stores in the market, making it difficult to find the source of the infection. Pang Xinghe, director of the Beijing Municipal Center for Disease Control and Prevention, and his colleagues analyzed the data of 3,000 people who visited the market between May 20 and May 30, and identified the source of the infection as sales floor 14. The “human infection” was eliminated. Subsequently, a joint collaboration between Tsinghua University, Peking University and other medical institutions determined that the source of infection was the packaging of imported frozen foods (Pang et al. 2020). The usage of big data in the investigation of infection clusters in the Beijing New Origin Food Wholesale Market led to the later discovery of a series of infection routes of imported products in different parts of the country.

11.5.2 Health Code

On February 4, 2020, the government of Hangzhou's Yu Hang District, China, issued instructions on the development of a health code. In response to the Hangzhou City Government's request for "orderly blockade management" on that day, the Yu Hang District Government wondered if an online health status declaration card-like tool could be built, with district government personnel taking inspiration from the Zhengzhou Corona Countermeasure Command's official WeChat account. It was emphasized that it should be "accessible to all people, all procedures can be done on the terminal at hand, and all areas can be linked" (Qianjiang Evening News 2020). He requested that this tool be made to track the exotic fluid population and provide some basis for decision-making on corona control. In response to this request, the Data Resource Management Bureau of Yuhang District and the District Political and Legal Committee formed a development team, and Alibaba and the startup company Maquankeji participated in the development meeting held on the evening of February 4. On February 5, at 5:00 a.m., the "Yuhang Code" was approved by a majority vote. This was the prototype of the "Yoke Code". Unlike the paper-based health declaration form, this application was equipped with a rudimentary screening function that allowed people to voluntarily declare their personal health status and movement history, and the system could also check the authenticity of the declaration, the infected area, and whether or not they had been in contact with a close contact.

On February 7, the Hangzhou municipal government issued a "Notice on the Resumption of Operations of Hangzhou Enterprises", announcing the resumption of operations from February 10 and the decision to establish a citywide unified "Employee Health Code". By 9:00 p.m. the next day, 335,000 registrations had been made, of which 269,000 had completed their information entry. On February 10, the "Yu Hang Code" was adopted by the human flow inspection gate in Yu Hang District, and was also activated by Alibaba's Alipay and Nail Nail. People are now able to pass through after presenting the code on their smartphone screens. The first 1,462 companies that were operating during the Spring Festival and the first 1,462 companies that resumed operations in Hangzhou applied for personal health codes on Nail. On February 11, the "Hangzhou Health Code," which added an automatic screening function between other databases to the "Yu Hang Code," began operating as a mini-program within Alipay. On February 17, Zhejiang Province and Shenzhen City began to adopt the health code, and on February 18, Wuhan City began to adopt the health code (CNNIC 2021).

The health code is the first typical bottom-up, integrated public–private innovation in China, developed by a private company at the request of the local government (Fig. 11.2). The public and private sectors are also working closely together in providing the system and using the service. The government database, cell phone location information from telecommunication companies, and customer usage history from railroad companies and airlines are combined and analyzed by the health code system, and then displayed in either "green-yellow–red" or "yellow–red" using QR codes developed by Denso Corporation of Japan (Marukawa 2020d). Green"

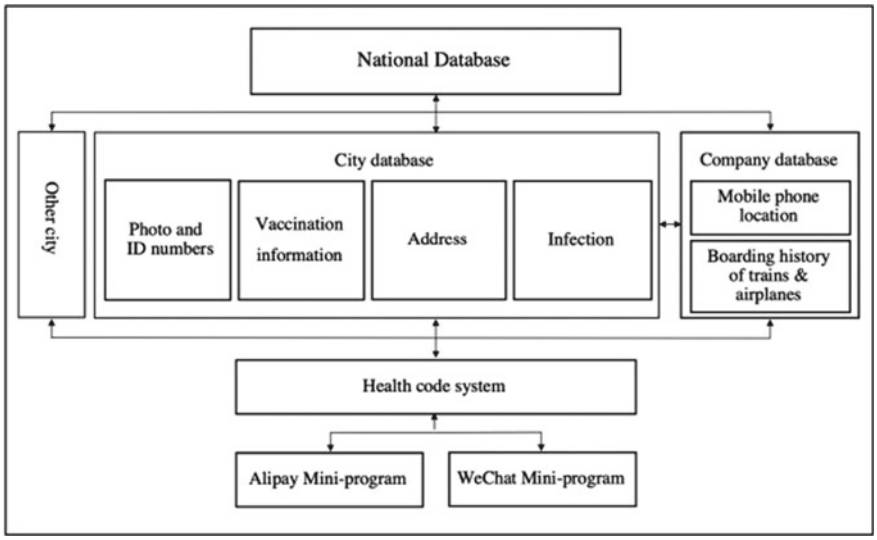

Fig. 11.2 Information sharing between public and private databases and health code system. *Source* This figure was prepared by t the author based on internal data of Dalian Municipal Government

means a non-infected person, "yellow" means a pseudo-infected person, and "red" means a contact or infected person. According to Marukawa, "You can't enter a department store or supermarket, a public transportation facility, or a workplace without holding up the green code, so the health code serves as a pass to prove that you are unlikely to be infected" (Marukawa 2020e).

11.6 Dalian's COVID-19 Response

There were cluster infections in Dalian, Liaoning Province, between July 22 and August 16, 2020, and December 22 and January 16, 2021.

11.6.1 Features of Dalian COVID-19 Response

11.6.1.1 Differences Between Wuhan and Dalian COVID-19 Response

In this section, we compare Dalian's corona countermeasures with those of Wuhan. Comparing the notice issued by Wuhan for corona countermeasures with the content of the commanding department order of Jinpu Xinqu District, Dalian, it can be seen that the countermeasures are more speedy and intensive. With an interval of about 12 months, three important differences can be observed in both measures.

First, in Wuhan, the main contents up to the No. 12 notice, which took 19 days to be decided after the lockdown, were covered by the Command Order No. 1 at the same time as the blockade was issued in Dalian.

Secondly, in Wuhan, the "relief for people in difficulty" was announced one month after the blockade, but in Dalian, it was realized the day after the blockade in the form of the establishment of daily commodities supply stations.

Thirdly, it is also worth noting that in Wuhan, purchasing daily commodities online was recommended, but in Dalian, it was replaced by direct distribution of commodities. This may be due to the accumulation of experience in implementing lockdowns in areas with cluster outbreaks throughout the country since Wuhan and the enhancement of response manuals.

11.6.1.2 Thorough "Liuwenliubao" Measures Before Infection Control

On January 28, 2020, the "Dalian Corona Measures Command Order No. 1" was promulgated in response to the Liaoning Province Command Order No. 1 (January 26). On February 26, the Dalian Municipal Market Supervision and Administration issued a "Notice of 30 Articles in Support of the Resumption of Operations" in response to the "10 Articles in Support of the Resumption of Operations" issued by the State Administration of Market Supervision and Administration (February 15) and the "Some Comments on the Resumption of Operations" issued by the Liaoning Provincial Market Supervision Bureau (February 25).

However, in reality, Dalian had been implementing thorough countermeasures against "Liuwenliubao" until July 22, 2020, when the first infected person was discovered and infection control measures were initiated. Since March, the Dalian Municipal Committee and the municipal government have been preparing for the resumption of operations with "Liuwenliubao" as the top priority. They established a restart team and an enterprise employment team, implemented 45 economic policies and 100 restart measures, 54 financial support measures, and provided 50.68 million yuan in subsidies to 1027 trading companies. As a result, by the first half of 2020, the operation resumption rate of foreign-funded enterprises in Dalian was 100%, the production rate was 107.6%, and there were 114 new foreign investments (People's Daily 2020e). Of this amount, 23% is for corona measures. Of this amount, 2.35 billion yuan was allocated for corona control (Dalian Municipal Government 2021).

11.6.1.3 Funding for COVID-19 and Emergency Measures for the Medical Community

Until the start of infection control measures on July 22, the main focus was on financing medical institutions and improving the medical insurance system; on January 31, the Dalian municipal finance department disbursed 10 million yuan

as emergency material funds. On January 31, the Dalian Municipal Finance Department disbursed 10 million yuan as an emergency fund; in addition, 20.52 million yuan were disbursed by the Dalian Municipal Government, 103.76 million yuan were disbursed by various financial departments of Dalian, and 126.53 million yuan was added in February (Dalian Municipal Government 2021), resulting in a total of 300 million yuan being raised as of February 28. A total of 430 million yuan in annual subsidies for medical institutions was also available for immediate use at this time (Bandao 2020).

The Dalian Medical Insurance Bureau also took a series of emergency measures and announced measures for patients, hospitals, and enterprises (Bandao 2020). It has decided on six points regarding patient treatment.

(1) The services and medicines in the corona treatment plan will be fully covered by the city's medical insurance.
(2) Patients from outside the city will be reimbursed on a deferred payment basis and treated under the same conditions as citizens.
(3) Government subsidies will be used to cover the full amount of individual costs for those with medical insurance.
(4) Those who do not have medical insurance can join after the fact.
(5) A 24-h telephone service for emergency hospitalization and treatment was set up for the outflow population. Furthermore, from December, during the blockade of Jinpu Xinqu District in Dalian, medical supplies can be delivered to the homes of residents in the area, and all personal expenses are fully covered by the medical insurance operating fund (Dalian TV Station 2020).

Hospitals were given preferential treatment in terms of medical insurance working capital, budgets, hospital beds, and accounts, and a total of 40 million yuan of working capital was paid in advance and paid directly to designated hospitals so that they could focus on treatment. The deadline for payment of basic medical insurance for employees of small and medium-sized enterprises was extended by three months, and arrears were waived. During this period, the company guaranteed that employees would be able to use their medical insurance and other services as usual (Bandao 2020).

11.6.2 COVID-19 Measures and Use of Information Technology in Dalian Community

11.6.2.1 Top-Down System from the Party Central to the People

On December 19, 2020, a new case of infection was reported in a carrier of a frozen food importer at Dalian Port. As soon as the route of infection was identified, the COVID-19 Order (No. 1) was promulgated at 10:00 a.m. on December 22, and the Advanced Road, Guangzhong Road, Ekimae Road, Friendship Road, and Retaining Road under the jurisdiction were blocked (Table 11.3). With this order, a state of

emergency was immediately set in place, and the Dalian Police Department and the local residents' committees were mobilized. The police blocked major roads and issued orders to close commercial areas, businesses, and factories, while the Resident Committee ordered all stores and stores within its jurisdiction to close. Citizens on duty were required to sleep and eat in the dormitories of enterprises, and enterprises without dormitories were uniformly closed. Citizens who were out were asked to return home immediately, and those who were at home were asked to refrain from going out completely.

The management and countermeasure system (Fig. 11.2) during the blockade was to be based on the regulations of the competent province, as in Wuhan. In contrast to Wuhan, in February 2020, five months before the outbreak of the cluster of infection, Liaoning Province promulgated "Article 30 of the Measures on Strict Inspection and Countermeasures in the Company Districts (Villages) of Townships and Townships in the Province" (Liaoning Daily 2020) and Dalian City promulgated "Notice on the Management of Housing Districts during the Corona Period" (Dalian Evening News 2020). The Dalian notice is a summary of all 24 articles of the social zone management notice issued by Hubei Province during the Wuhan blockade, excluding those related to the management of infected people, which are summarized in 10 articles. Article 30 of the provincial measures lists "10 items to be strictly checked, 10 items to be required, and 10 items to be avoided by residents". Of the 30 articles, the first 20 were orders to the community, and the last 10 were requests for cooperation from residents. Immediately contacting the district if a fever is detected; taking appropriate medical treatment at the right time; wearing masks, washing hands, and ventilation; and not hoarding daily necessities.

11.6.3 Overcoming Database Problems

During the first lockdown, there was no data sharing between public health, public security, customs, and telecommunication companies. Therefore, personal declarations by citizens were promoted. However, there were problems with the accuracy of the information collected, forcing the city to adopt a method of having citizens submit relevant information, which was then reconfirmed by public security and the community (Wu 2020). during the second lockdown, the community collected personal information of residents and entered it into the city database, and only the public security Only the Bureau of Public Safety was allowed to use the Big data.

11.6.4 Surveillance and Drones

During the blockade period, police officers in protective gear, residents' committee members, police cars, and ambulances were always on standby near the entrances to the housing complexes. The purpose of this was to be able to respond immediately

in case of fever or other problems. Deliveries of daily necessities to citizens were checked in detail, including the time of arrival, departure, and destination. At times when these checks were not necessary, or at night, the system was switched to drone surveillance. In the event that a person went out without permission, he or she would be detained and punished by the police bureau in accordance with the orders of the Jinpu Xinqu District Commanding Department, and everyone in the apartment complex would be counted again for isolation for "14 days + 7 days" from this point on. If the situation requires isolation in a facility other than the home, all expenses incurred will be borne by those who have gone out.

During the Wuhan response, many drones were deployed. Since it was necessary to control the body temperature of people waiting at home, direct contact was avoided, drones were used to make aerial announcements, and drones were used to check the temperature of people with open windows. The reason why there was not a lot of drone surveillance in Dalian was because all those who came into contact with the disease were placed under intensive observation at designated hospitals and facilities, and the blockade of housing complexes was considered to be a restriction on the movement of people with low infection potential. Another reason is that the CCDC issued a notice on January 26, immediately after the Wuhan blockade, instructing the community to "maintain communication with all households," so that by the time the Dalian blockade was issued, the community had already established a direct WeChat connection with the residents under its jurisdiction and had a means of two-way communication at all times.

11.6.4.1 Daily Operations of the District as Seen Through WeChat

After the blockade was issued, the community forwarded the commanding department's order on WeChat's "Subdistrict Service" and switched all business to non-face-to-face. The previous "subdistrict service" WeChat groups were further subdivided into groups for each building, and at least one person from each generation was instructed to join. It was during this period that the author joined a group of grid managers in charge of three buildings, Nos. 32, 34, and 348, located in Shengli Road Huayuan Subdistrict, Jinpu Xinqu District, Dalian, with a total of 162 households and 563 people. This section is organized based on the information obtained from the group participation and informal interviews with three residents up to September 2021.

The female grid member representing the community was a resident of Building 348 and was assigned the role of reporting to the top about the problems and requests of the residents of the three buildings, in addition to communicating notices and instructions from the top (Fig. 11.3). As a representative of the community, she was responsible for providing service to the residents from beginning to end. She was also a familiar presence for the residents, whom they could contact and consult about any problems they had. She is also a person that residents can contact for any problems. During the lockdown, most of the calls were related to daily commodities, but there were also daily inquiries about whether it would be better to report to the

community about visitors from outside Dalian who came to a neighbor's house just before the lockdown, requests to repair the electricity in the stairway, inquiries about the community's phone number, and how crowded the vaccination hall was. She was the only non-resident to contact me on a daily basis. In addition to the residents, she communicated daily with the publicity, information, general affairs, and hygiene groups (Fig. 11.3). She contacted the general affairs group for the shortage of daily commodities, the publicity group for mental counseling such as not being able to go out or for corona control, the information group for the latest information, and the hygiene group for disinfection.

Based on the findings of her nine months in the group and the interviews with the grid members, she concluded that the community is very friendly to the residents, tries to solve their problems and provides better services to them, and she herself is not afraid of taking care of details and takes pride in her work.

11.7 Conclusion

(1) It was not until the failure of the initial response in Wuhan that the importance of primary information in the medical field was reaffirmed that information technology was thoroughly utilized in China's corona countermeasures. In parallel with the promotion of information disclosure, the establishment of a national database was promoted to make it easier for information from the field to reach the central government, and to ensure smoother information transmission. Overconfidence in the power of science was another factor in the failure of the initial response. While it is easy for a centralized state like China to exert strong leadership, it also tends to demand that the information on which it bases its decisions be scientific and legitimate. The importance of scientific evidence is indisputable, but at the same time, the collection of information on the actual situation on the ground is also essential. It can be said that the initial response in Wuhan sufficiently verified the point that such comprehensive information management is necessary in China.

(2) Post-COVID-19 economic policy was set as a challenge during Wuhan's corona control period. This agenda setting contributed greatly to the economic development of China after COVID-19. This is because most of the regions other than Wuhan, including Dalian, were required to take measures against "Liubaoliuwen" before infection. Until full-fledged infection control measures were implemented, there was enough time to implement economic measures ahead of time, and the economic damage caused by COVID-19 could be minimized. In other words, the recovery of economic activity was accelerated because the economic measures were able to take the lead in COVID-19 countermeasures. And China is still moving in the direction of developing its economy and taking full-fledged COVID-19 measures when the infection appears.

(3) Another new insight was gained from the discussion of Dalian. As indicated by Article 30 of the measures from Liaoning Province, it was a unilateral and

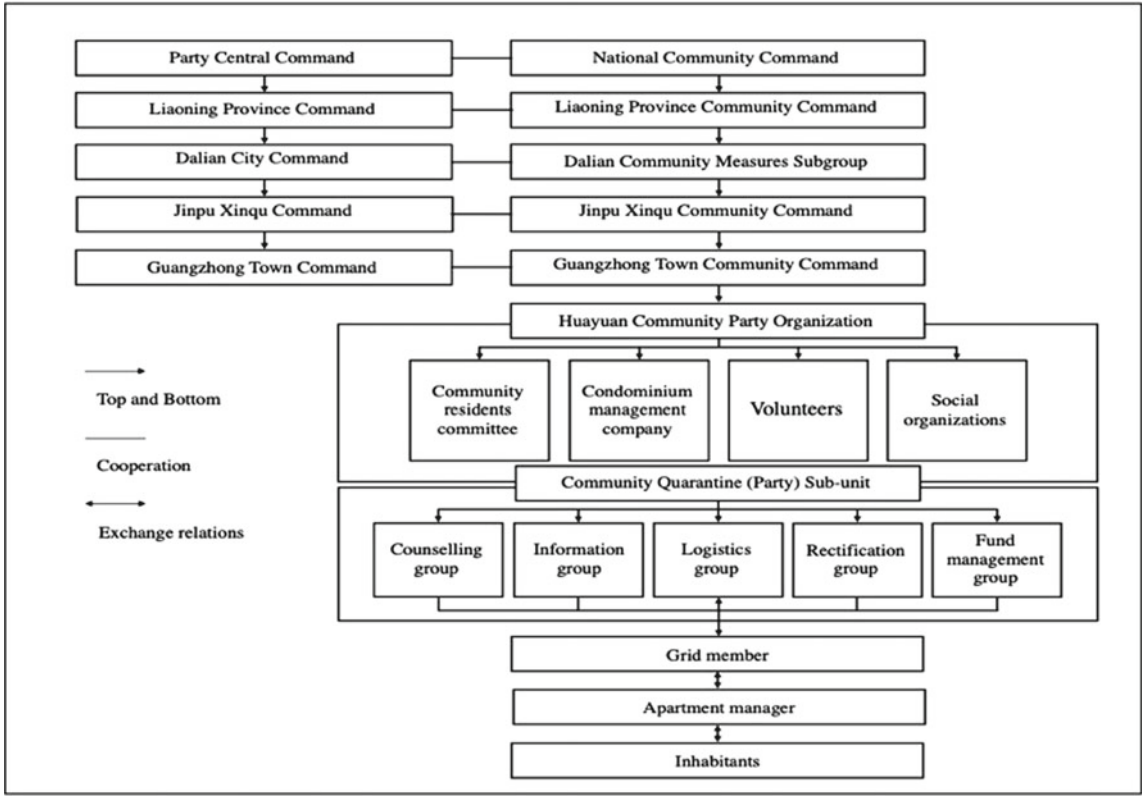

Fig. 11.3 Corona response system from central government to residents. *Source* This figure was prepared by the author based on materials from the State Council of China and interviews

repressive order starting with "strict" and "mandatory" up to the city, district and community, while the residents below the community were asked to cooperate except for movement restrictions. Generous emergency measures were also put in place by the medical community to ensure that everyone had access to medical care. It is believed that the role of the community is to provide thorough services to every corner of the residents' lives, and the community is the closest to the residents and they can rely on the community to do everything for them. Even after the lockdown is lifted, the community and grid members continue to provide services.

(4) As a result of the analysis in this paper, we can conclude that "leadership", "science", and "cooperation" are three important factors in the Chinese model of COVID-19 control. It can be said that China's quick response to COVID-19 was made possible by its strong leadership, which was able to take quick action from the moment the "human infection" was confirmed. In addition, because we were able to conduct scientific analysis using big data and effective public–private partnerships, we were able to trace the flow of people from Wuhan and quickly determine the route of infection from frozen food in Beijing, and we were able to change course as early as February 6 and come up with economic measures that contributed to China's later economic development. In the vast country of China, a wide range of social cooperation systems, public–private integrated social governance, and public–private integrated innovation such as the health code will be important for future economic development and the application and development of technology. However, as the fight against new coronavirus infections is still ongoing around the world, it is necessary to keep abreast of the latest developments, such as mutant strains, and to take appropriate measures accordingly.

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Chapter 12
Jugaad Innovation: Concept and Lessons of Social Innovation in India

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Abstract Jugaad originates from the Indian language of Hindi that vaguely means the courageous act of improvising an effective solution with the limited possible resources to overcome the harsh constraints. Often considered to be a rough, informal innovation, Jugaad helps address social problems and blends seamlessly with the Sustainable Development Goals and the Society 5.0. This chapter looks at Jugaad from an innovation perspective, taking the entrepreneurial lens of Jugaad through the Bricolage Theory of Entrepreneurship. Five independent cases are selected for this study to showcase the behaviour of jugaad innovations in solving a social problem and the process of the jugaad becoming a core value of the firm. These cases were selected based on purposive sampling. The selected cases were recognised by the National Innovation Foundation, Government of India in their initiative to enhance grassroots technology breakthroughs and excellent traditional knowledge. The cases address the Sustainable Development Goal-12 Responsible Consumption and Production and analyse how the innovations address Society 5.0, including use of resources, people-centric societies, merging of cyber and physical spaces and knowledge-intensive institutional structures that can enable scalability of Jugaad innovations, and sustainability of Jugaad innovations.

Keywords Jugaad innovation · Improvised solutions · Social innovation · SDGs · Women empowerment

12.1 Introduction

Society 5.0 is a society that greatly integrates cyber and physical space centred on human with the aim of addressing social problems along with economic advancement (Cabinet Office, Japan 2021). The 5th Science and Technology Basic Plan proposed

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the idea of Society 5.0 as a Japan's future society. The predecessors of Society 5.0 are information society (Society 4.0), industrial society (Society 3.0), agricultural society (Society 2.0) and hunting society (Society 1.0). As per Society 5.0, the social reform (innovation) is achieved through forward-looking society where each person can lead an active and enjoyable life with mutual respect irrespective of generations (Cabinet Office 2021). Furthermore, achieving greater convergence between physical space (real space) and cyberspace (virtual space) is the main objective of Society 5.0 that is expected to utilise for disaster risk reduction (DRR).

Jugaad blends seamlessly with the concept of Society 5.0. The word comes from the Indian language of Hindi that broadly means the courageous act of improvising an effective solution with the limited possible resources to overcome the harsh constraints (Radjou et al. 2011). Similar to frugal innovation, but more local and cost-conscious approach, Jugaad refers to innovation that renovates products and services to build more inclusive markets by using resources divergently and address consumer's affordability constraints that could contribute to community resilience.

This chapter reviews the state-of-the-art literature on Jugaad and frugal innovation and highlights case examples from the perspectives of sustainability and financial inclusion. The objective of this study is to explore the values Jugaad innovations bring to the social innovation ecosystem of India. It mainly focuses on Jugaad contribution in addressing SDG7 (affordable and clean energy), SDG8 (decent work and economic growth) and SDG12 (responsible consumption and production) with the help of Bricolage theory of entrepreneurship and relevant case studies. The chapter showcases the merging between cyberspace and physical space, the balance of advancement and resolution of social problems by providing affordable and local goods and services, and highlights the relationship between technology and society.

The methodology in the chapter involves, (a) literature review of Jugaad innovation in the social ecosystem, and (b) case studies where five independent cases are selected to showcase the behaviours of jugaad innovations in solving a social problem and the process of the jugaad becoming a core value of the firm. These cases are selected based on purposive sampling. The selected cases are recognised by the National Innovation Foundation, Government of India in their initiative to enhance grassroots technology breakthroughs and excellent traditional knowledge. The cases address the Sustainable Development Goal-12 Responsible Consumption and Production and analyse how the innovations address Society 5.0, including use of resources, people-centric societies, merging of cyber and physical spaces and knowledge-intensive institutional structures that can enable scalability of Jugaad innovations, and sustainability of Jugaad innovations.

Jugaad is often considered as crude form of innovation but its value addition to the social ecosystem is overlooked. This chapter explores the potential of jugaad in addressing sustainability goals with minimum possible resources and moving towards society 5.0. This study marks implications for Indian policymakers for these niche group of innovators who often are ignored in the current society but are integral contributors to Society 5.0.

Highly resource-constrained environments inspire *jugaad.* The innovator who practices *jugaad* develops products and services that are affordable, sustainable and

market relevant. *Jugaad* innovators seek opportunities in the adversity and create value for their organisations and communities (Radjou et al. 2011). The ideas of frugality, jugaad and sustainability are interrelated (Khan 2016), and jugaad or frugality can be seen as a characteristic of sustainability. *Jugaad* offers new solutions for products, services and processes aimed at low-income customers in emerging markets, improving local societies wellbeing, minimising the use of resources (material, financial, technological), affordable, and improved quality despite resources limitations.

The principles and practices of *jugaad* mindset are highly relevant for the present world which is aspiring to grow in the resource constraint environment and achieve sustainability. The fluent jugaad approach aims to achieve agility, speed and cost efficiencies unlike traditional innovation methods that are structured, time-consuming and costly R&D processes. Jugaad offers a "bottom up" innovation approach to succeed in a hypercompetitive and advancing world for organisations especially in developed and developing economies.

In this chapter, we highlight how Jugaad develops affordable and quality solutions to low-income consumers in a resource-constrained environment. We argue for Jugaad not being a mere strategy but a flexible approach to thinking about repurposing and sustainable resourcing. We view Jugaad as an entrepreneurial mindset that has the ability to develop innovative solutions using limited resources for underserved consumers typically in low-income to middle-income surroundings and communities.

The next section discusses the concept of *Jugaad* and the manifestations and measures of frugal innovations, followed by underlying theory and framework of jugaad innovation. Later the methodology approach adopted to this study is discussed followed by five case studies on jugaad innovation in the Indian scenario falling under SDGs. The last section brings out the discussions on future trajectories from the lens of bricolage theory.

12.2 Jugaad: A Review of the Concept

Jugaad indulge in rapid prototyping through collaborating with customers to build product and service features instead of being pre-planned, linear and time-consuming R&D processes. Jugaad innovations are considered as frugal because they develop new solutions on existing infrastructure and resources instead of spending on costly R&D projects and reinventing the wheel. In doing so, they also recombine the existing solutions and transfer the cost savings to their customers.

Jugaad innovators perceive that emerging markets consumers are low earners, yet aspirational for good quality and diverse products. *Jugaad* innovators strive to develop solutions of superior value which are affordable to meet customers' high aspirations that is delivering more (value) for less (cost). Therefore Jugaad innovators are highly adaptable because they sense and respond to swift changes in their surroundings by dynamically reinventing their business models and products.

Inclusivity and optimal resource capture is an inherent part of Jugaad. In India, millions of people are unbanked, lack access to healthcare and electricity. These marginal segments are considered as unprofitable by most corporations whereas jugaad innovators are serving these sections profitably by inventing inclusive business models. These entrepreneurs perceive great business sense along with greater social good by serving the margin.

12.2.1 Manifestations and Measures of Frugal Innovations

The resource constraints and their increasing scarcity give rise to the idea of frugal innovation. Innovation can be termed as frugal when it brings in efficiency and effectiveness amidst resource constraints. They develop products and services which aim to address the economic, social and environmental needs through effective and efficient utilisation of limited resources. Frugal innovations are mostly developed with the limited resources and they are resilient, easy to use and affordable. They are induced by demand and low-cost competition especially in emerging economies where resources are scarce. The solutions of frugal innovation can be used in sectors, such as health care, transportation, energy, communications, banking and water.

Frugal innovation is a comprehensive term which has some common characteristics of frugality and low cost with other innovation concepts such as jugaad, resource-constrained innovation, base of the pyramid innovation, reverse innovation, grassroots innovation, cost innovation and disruptive innovation (Soni and Krishnan 2014; Hossain et al. 2016). Furthermore, sustainability transition is a conscious thought among the innovators as they move towards jugaad and frugal innovations.

The desire of improving the wellbeing of local societies, minimising the use of resources, low cost generating, inclination towards new solutions for products, services, processes and business models, targeting low-income customers of emerging markets and improving the quality standards are the driving factors of frugal innovations (Zeschky et al. 2014; Radjou and Prabhu 2015; Hossain 2017).

According to Ahuja and Chan (2014), the frugal innovation is a combination of three other kinds of innovations that are, social, business and technology. Social innovation aims to solve social problems to bring in sustainability and create values for societies (The Center for Social Innovation at Stanford University 2014). Business innovation aims to redefine business models and reinvent value chains (Ahuja and Chan 2014). Technology innovation is related to strengthening goods and services by technological development (Ahuja and Chan 2014).

12.3 Theory and Framework

The study attempts to look at Jugaad from the lens of Bricolage Theory for Entrepreneurship. Levis Strauss (1966) introduced the concept of Bricolage meaning

"making use of whatever is at hand". The author compared an engineer to aboriginals who have entrepreneurial skills similar to civilised society. For example, when an engineer requires certain resources such as metal, motor, spindle, etc. to build a washing machine, the same can be made by a bricoleur with proxy materials to substitute the action for a functioning washing machine. Further, Baker and Nelson (2005) explained the bricolage theory from the perspective of entrepreneurship, illustrating that stringent resource constraints and economically depressed conditions give rise to novel entrepreneurial ventures. The concept of making something out of nothing is the key tenet of this theory which closely resembles the concept of Jugaad. Taking the example of the washing machine (Fig. 12.1), an innovator/jugaadu invents a working washing machine mimicking the working of a motor and a spindle by connecting it to the bicycle. While the output remains the same of washing clothes, the means to achieve the end varies, the jugaadu's method utilized minimal resources to develop a washing machine.

Bricolage has been utilised in the entrepreneurial literature to conceptualise market development (Baker and Nelson 2005) and nascent business growth (Baker et al. 2003). Bricolage is a term used in the innovation literature to illustrate how resilient solutions may be generated in unpredictable situations (Ciborra 1996; Garud and Karnoe 2003). Bricolage is the process of building something out of nothing by

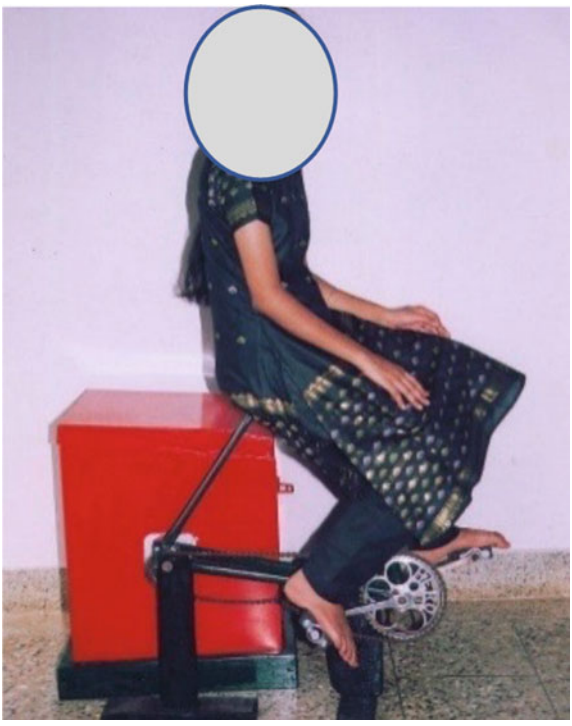

Fig. 12.1 Pedal driven washing machine. *Source* BrightVibes

improvising with what is available to solve issues and identify opportunities (Baker and Nelson 2005).

Baker and Nelson (2005) inductively develop a model for bricolage theory of entrepreneurship by proposing that when entrepreneurs are antagonised with penurious environments-settings that pose new problems without supplying additional resources, entrepreneurs tend to behave in three of the ways (Fig. 12.2). Firstly, to look for resources outside of the company; Secondly, to remain inactive, downsize or disband in order to avoid fresh obstacles; Lastly, to practise bricolage by making do with whatever materials are available and applying them to new problems and possibilities. The ones who choose the last option, have an option to execute bricolage in either physical inputs (materials with novel use-value), labour inputs(involving stakeholders view), skill inputs (contemporary skill utilisation), customer/markets (providing products/services) and regulations(actively attempting irrespective of the legalities)(Fisher 2012). Further, in the long run, certain firms practicing parallel bricolage generate mutually reinforcing patterns across the domains working on resulting in stalled growth. In contrast firms that involve in selective bricolage focus on fewer domains thereby escaping the reinforcing dynamics and hence able to taste success over time (Baker and Nelson 2005).

While parallel bricolage and selective bricolage lead to absence and presence of growth, (Shepherd et al. 2020)in the realm of an innovation within the resource-constrained challenges the jugaadu's firms often show no/low firm growth but high inclusive growth. A jugaadu's product is often associated with poor marketability, non-scalability and are highly imitable which results in low firm growth. However, in the context of inclusive growth the jugaadu firm/innovation helps other users, fosters employment and provides benefits through the social innovation. Thereby a matter of concern is the future of such jugaads and jugaadu firms and what interventions can enable better growth for these jugaadu firms.

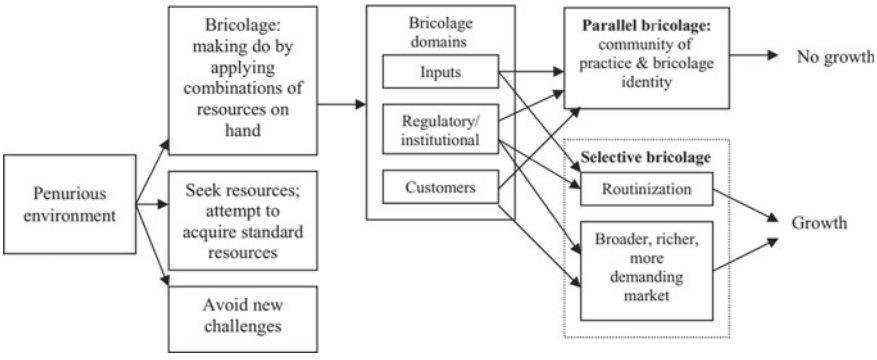

Fig. 12.2 Bricolage approach to entrepreneurship (Baker and Nelson 2005)

12.4 Research Methodology

This research takes a multi-case study strategy. This method is useful for gaining insight into social processes and providing a description of a phenomenon (Eisenhardt and Graebner 2007; Yin 2009; Onwuegbuzie and Leech 2010). This multi-case study is an in-depth and extensive analysis of a subject of investigation along with its surrounding circumstances. Data gathering from a number of examples (approximately four to ten) is essential, as this will provide a more solid foundation for theory development and a trustworthy justification for the findings (Eisenhardt and Graebner 2007; Curtis et al. 2000; Yin 2009).

Five independent cases are selected for this study to showcase the behaviour of jugaadus in solving a social problem and the process of the jugaad becoming a core of a firm. These cases were selected based on purposive sampling, these cases were recognised by the National Innovation Foundation, India. It comes under the Department of Science and Technology, Government of India where it is the nation's initiative to enhance grassroots technology breakthroughs and excellent traditional knowledge. The cases were selected such a way that the innovations addressed the Sustainable Development Goal-12 Responsible Consumption and Production.

The first case introduces mobile money as an innovation to target the bottom of the pyramid. The next case looks at how a juice vendor innovated fruit covers to be used to serve juices. The third case addresses the usage of clay to store fruits and vegetables. The next case illustrates the innovation of sanitary pads and last case addresses an innovation that optimises and simplifies the process of weaving a traditional silk sari (a traditional dress of India). The cases serve as examples for social innovations addressing issues of sustainability, inclusiveness and empowerment.

12.5 Case Studies

This section highlights case examples from the perspectives of sustainability and financial inclusion.

12.5.1 Mobile Money as a Jugaad *Innovation for the Bottom of the Pyramid*

The financial services accessed electronically through mobile phone are termed as mobile money (Gencer 2011). The concept of mobile banking and mobile money are different although they are used synonymously sometimes. Mobile banking refers to accessing traditional bank accounts through mobile devices whereas mobile money is a payment system which includes store of value, payment instrument and channel that enables financial services such as savings, insurance, payments and credit using

universal mobile technology. Mobile money services act as default payment systems of market with immature financial systems. This reduces the transaction costs, enhances access to financial services, reduces the use of cash and thus transforms informal markets. Mobile money is enabling access to formal financial system by bridging the gaps in financial systems.

Mobile money redesigns the traditional financial services by bringing the financial services on mobile platform with higher accessibility, affordability and easy to use for consumers along with profitability and sustainability to service providers. Due to this nature of serving the bottom of pyramid, the mobile money is considered to be frugally driven business model. Mobile money helps in better inclusion than the traditional financial services. The mobile money is a form of jugaad innovation that serves customers profitably and sustainably. Mobile money adds value to the financial system through increased access, affordability and other socio-economic benefits to both customers and mobile money service providers (Bhatti and Ventresca 2012).

Mobile money can be conceptualised as a *Jugaad* innovation along three dimensions. (1) Technology innovation that targets emerging markets and consumers amidst resource constraints. (2) Financial innovation that addresses the constraints of affordability. (3) An innovation that addresses the institutional voids. New business models have evolved from mobile money initiatives which address the business constraints of value capture and value creation which is nothing but a frugal innovation.

Information and communication technology (ICT) facilitated low-cost and value-sensitive design innovations can be considered as frugal innovations (Howell et al. 2018). According to Rao, the frugal products and services such as mobile money address the concerns of design and spares. Many research studies indicate that mobile money can be an inclusive innovation for emerging economies (Gencer 2011; Donovan 2012; Kama & Adigun 2013; Kim 2017; GSMA 2017, 2018; Demirguc-Kunt et al. 2015).

12.5.2 Addressing Sustainable Development Goals: Eat Raja

Eat Raja in Bangalore is India's first zero-waste quaint juice bar run by Mr. Anand Raj. His father started the juice shop, one of the earliest in the neighbourhood and known for its cold-pressed juices. Anand Raj completed his engineering degree and became a prominent radio personality in Bangalore, with a strong passion for environment. With the untimely passing away of his father, Anand Raaj left his job as a radio personality to assist his mother in running the juice shop.

However, he wanted to introduce something unique and novel when he took over. Taking forward his care and passion for the environment, he chose to make the cafe a zero-waste zone. He adopted a Zero Waste policy and developed a revolutionary idea of serving his juices in the remains of the fruit itself. He used his technical design skills to carve out the fruits in the right form to keep the liquid inside and serve as a cup for the juice (Fig. 12.3).

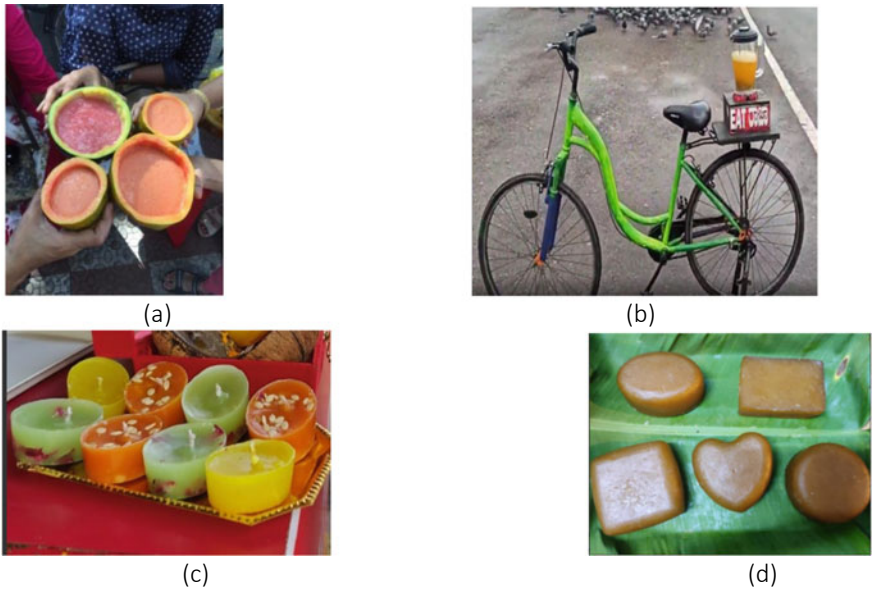

Fig. 12.3 Products served at Eat Raja; **a** fruit juices being served in fruit shells, **b** the cycle mixie, **c** candles made of fruit waste and **d** soaps made of mango waste. *Source* EAT RAJA (@eat.raja) • Instagram photos and videos

Anand Raj says "*I decided on the concept of 'Eat Raja- Amma Maadiddu (Mother made)', which means whatever you will get here will be homemade. I have seen how the business used to generate a lot of waste earlier—be it in terms of cups, straws, PET bottles and carry bags. When I took over, I had decided to get rid of this legacy of waste, and that's how our journey from being a humble juice shop to becoming Bengaluru's first zero-waste juice corner took place*".

As an initial step, he started by refusing single-use products, and separating wet and dry waste. As a next step, he banned plastic bottles and straw, which make up a significant portion of dry waste. He began utilising steel and leaf straws instead of plastic straws. Further on, as a significant move, instead of using cups or glasses, he began serving liquid savouries in the fruit shell itself.[1] After use, citrus fruit shells are separated into two bins: one for citrus fruit shells and the other for non-citrus fruit shells. Animals are fed non-citrus fruit shells. Citrus peels are used to generate bio enzymes that clean steel straws and are also used to make floor cleaners, PET washes, and detergents. Apart from juices, he sells his mother's homemade food, such as masalas. He sells bio enzymes and detergents as well.

Anand Raaj has created a "cycle mixie" to promote waste management and energy conservation concepts. The invention is made of recycled materials and operates on a

[1] According to the Sustainable Development Goals Report the global material footprint has increased by 70% between 2000 and 2017. Approximately 1 million plastic drinking bottles are purchased every minute and close to 5 trillion single use plastic bags are thrown away each year.

second-hand cycle. Customers can churn their own juice by pedalling the stationary cycle. The mixie at the back is a product that would have been thrown away if it hadn't been attached. "*If the change has to happen, it should begin with oneself, and I don't make huge profits. But, I don't want this to fail because it might put down people who would want to adopt a zero-waste policy*" says Anand Raj.

12.5.3 Addressing Sustainability and Inclusion: Mitticool

Mansukhbhai Prajapati hailed from a family who earned a living through pottery at Morbi, a small town in the state of Gujarat, India. His father did not find this business lucrative and sent Mansukh bhai to school with the hope that he would earn better livelihood. Unfortunately, Mansukh bhai could not clear his qualifying board exams, and took odd jobs for a livelihood. He soon decided to get back to his family profession. The devastation during the Gujarat earthquakes of 2001 changed the course of his life. Reading a newspaper headline "*Garibi ka fridge toot gaya- (the fridge of the poor has broken)*", got Mr. Prajapati thinking and decided to invent a refrigerator which the poor can also afford. "T*he rich can buy anything but the poor cannot afford products like the refrigerator. So I thought why not make something the poor can afford and use*," says Mr Prajapati.

He innovated Mitticool, a clay-based natural refrigerator for storing veggies and fruits as well as cooling water. Mitticool maintains the stored material's inherent coolness without the use of electricity or any other artificial kind of energy. Inside this clay refrigerator, the temperature is nearly eight degrees lower than outside. Vegetables can last up to four days in the refrigerator, while milk can last up to two days. Its dimensions are 26 inches long, 15 inches wide, and 12 inches deep, and it takes up very little kitchen space. The product saw early success and has sold more than 9000 units across India. Priced a little over Rs. 3000 it is a veritable poor man's fridge.

He then went on to study the current non-stick coating technologies and became an expert at producing alternate option for clay pans. He has invented two other products, namely,

- Anon-stick pan and then gradually went from one clay alternative to another. Non-stick coated Tawas are an important utensil of any kitchen for preparing low-oil meals, but Non-stick coated tawas are expensive and have a one-year life span.
- Clay cookers are a clay-based cooker with a simple whistle to release the additional pressure that builds up inside the pot during cooking. For handling the cooker, it features a backlit handle. It contains two clamps and a rubber ring to secure the cooker lid.

Mr. Prajapati quickly developed a full line of earthenware goods for everyday use in the kitchen. Water filters, refrigerators, hot plates, cookers, and other everyday things are among these products (Fig. 12.4).

Fig. 12.4 Mitticool products **a** clay-cooker, **b** non stick earthen tawa, **c** refrigerator. *Source* Microsoft PowerPoint—case-study-on-mitticool.ppt (gian.org)

12.5.4 Addressing Inclusion: Padman

Arunachalam Murugananthamhas created a low-cost sanitary-pad-making machine, thus, ushering in a sea change in the lives of women throughout India. Born in 1961 to handloom weavers, Murugananthamʼs father died in a car accident while he was a child, and he grew up in poverty. He drop out of school at 14 years to support his family. He sold meals to factory workers and worked as a machine tool operator, yam-selling agent, field labourer and welder.

Married at the age of 37, Murugananthamsaw his wife collecting filthy rags and newspapers to use as sanitary napkins during her menstrual cycle because sanitary napkins by multinational corporations were prohibitively expensive. He began creating experimental pads, using his wife and sisters as test subjects for his experiments. He realised that the raw components cost ten dollars (thirteen dollars in the United States), but the finished product sold for forty times that amount. Murugananthamsought female testers for his innovations, but most were too embarrassed to discuss their menstruation problems with him.

In general, menstruation is taboo in India and Murugananthamwas shunned by his society and family. He gave away his wares for free to girls at a local medical school in the hopes that they would provide feedback. Two years later, he figured out that the commercial pads were made from cellulose fibres obtained from pine bark wood pulp. The fibres allowed the pads to soak while yet maintaining their form. The pads were produced on imported machinery that cost 35 million (US$460,000). He created a low-cost equipment that required little training to operate. He got the processed pine wood pulp from a Mumbai supplier, and the machines would grind, de-fibrate, press and disinfect the pads before packaging them for sale (Fig. 12.5).

His invention took a massive positive turn in 2006 when he presented his idea at an academic conclave. The professors submitted his innovation for the Grassroots Technological Innovations Award from the National Innovation Foundation, and he won the award. He used the award money to start Jayaashree Industries, to sell similar devices to women in rural India.

His commitment to social service has garnered him multiple accolades, and the machine has been acclaimed for its simplicity and cost-effectiveness. Despite offers

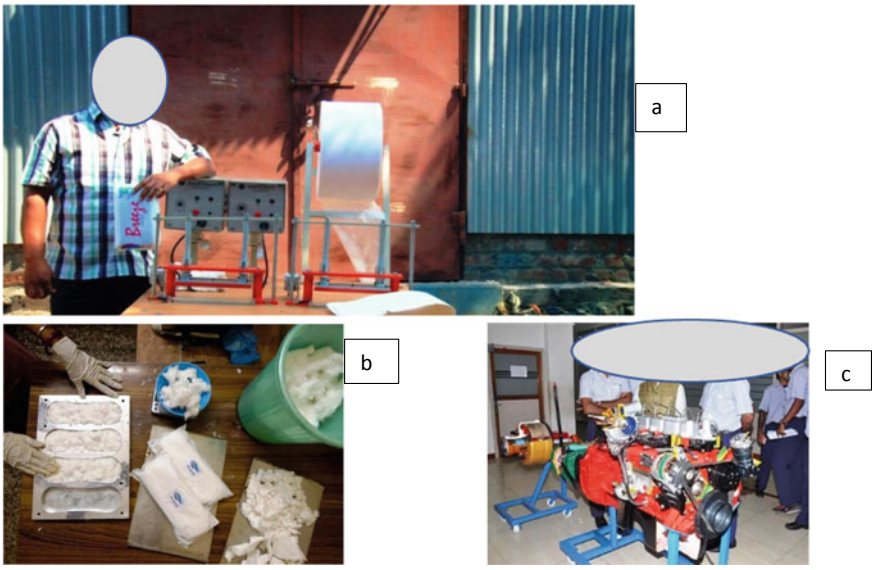

Fig. 12.5 **a** Arunachalam Muruganantham's first machine; **b** material used in the pads **c** large-scale productive plant. *Source* 18 Interesting Facts About Arunachalam Muruganantham (Padman) | OhFact!

from various corporations to commercialise his innovation, he has declined and continues to supply these machines to women-led self-help groups (SHGs).

Muruganantham's idea is widely regarded as a significant milestone in improving the lives of Indian women. Many women benefit from the machine since it provides jobs and cash, and affordable pads allow even more women to work throughout their periods. Each of Muruganantham's machines employs ten people and converts 3,000 women to the use of feminine hygiene products. Each machine can generate 200–250 pads each day, with each pad selling for roughly 2.5 rupees ($0.03) on average.

12.5.5 Addressing Women Empowerment: Laxmi Asu Making Machine

The Pochampalli1 silk cloth material (textile) is a beautiful weaving tradition with a wide range of colours and sophisticated geometrical patterns, the distinguishing feature being the design on the front and back of the cloth material are the same. Hand winding of yarn, known as Asu, is an integral and critical technique required before the patterns are weaved on the loom. The method entails moving one's hand 9000 times around semi-circularly set pegs across a one-metre distance, requiring extreme concentration and accuracy. Almost four to five hours are required for each sari. The Asu technique is responsible for the entire design of the saris.

This practise was traditionally conducted by family members while sitting in the shade or at home. However, it necessitated long hours and a great deal of physical exertion. Designs are marked on the threads and tied appropriately after the Asu process, and then dyed in selected colours. Coloured threads are spun on spindles and woven into saris on looms, embracing the lovely designs and patterns of this tradition.

Mallesham, a traditional weaver, has devised a mechanism to automate this procedure and relieve women of the drudgery associated with it. Born in a family of traditional weavers in Sharjipet, a small community of handloom weavers, Chintakindi Mallesham, started weaving from the age of ten. He completed his studies till seventh grade and enrolled in private tutoring to complete class tenth. However, due to family's financial difficulties, he dropped out of school. Though he didn't have much time for other activities, he enjoyed disassembling broken radios and transistors to examine the internal components.

He saw his mother doing the Asu for the saris that his father and he wove. Her shoulders and elbow joints were in excruciating discomfort as a result of this. Mallesham had little experience with mechanical or electrical technology, but had a deep desire to alleviate his mother's suffering, which motivated him to move forward.

At the age of 20, this young entrepreneur began his dream enterprise. He got to work on the concept and separated the entire procedure into five sections. He constructed and connected mechanical devices to a wooden frame piece by piece. Earning, saving, and spending on his project became a four-year cycle for him. He married Swarna at the age of 24. His wife backed him up by donating whatever money she had, helping him successfully complete three portions in 1997. However, he had exhausted all the resources by that point, and hence put down his loom and went in search of another job.

Working in a machine shop, in 1999, he began to observe the machine with deep interest, identifying a movement in one that was comparable to what he needed in his machine. Getting the component made to meet the specifications, the components were fitted to the machine, and the machine functioned. The quality of product was distinctly superior to that attained using the hand-operated Asu technique. The news travelled quickly.

In end of 1999, the first machine was built on a wooden frame. The next year, the same was changed to steel, followed by sales of nearly a hundred machines each year from 2002 through 2004. In 2005, he included a number of electronic components to boost the automation process. The number of threads on each peg can now be changed as well. Noise was reduced by over 90% as a result of these adjustments. The new design also reduced the amount of electricity used. The time taken to finish one sari has been lowered from four hours to one hour and thirty minutes.

Given that the majority of weavers would be unable to purchase the new machine, Mallesham took great care to include adjustments that would not increase the price. Over the previous few years, he has sold over 300 of these machines (Fig. 12.6).

In the year 2000, he founded a workshop with the support of his brother and other family members to manufacture Asu machines for the weavers. Separate work facilities dedicated just to Asu have sprung up, primarily as a result of people who

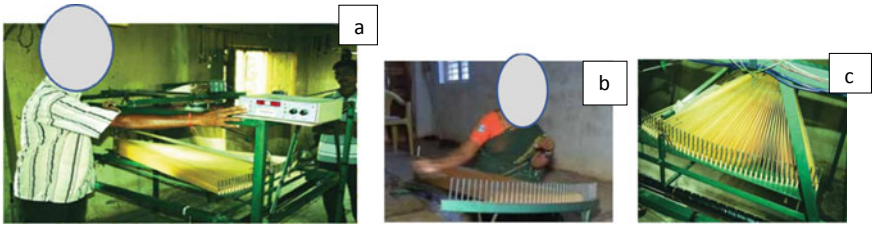

Fig. 12.6 **a** Mallesham with the Asu Machine, **b** hand winding, **c** machine winding procedure of yarn

could not afford a loom. Ladies who had previously worked in the manual Asu process have now learned to weave on looms in the same way that men do.

12.6 Discussion—Future Trajectories from the Lens of Bricolage Theory

This section elaborates on the future trajectories of each of the cases from the lens of Bricolage theory. Table 12.1 tabulates the cases and the trajectories for future to leverage on the innovation using bricolage theory. The discussion highlights how cyberspace and physical space merge to bring benefit to the society and balancing economic advancement and resolution of social problems is possible through Jugaad innovations. Furthermore, the cases highlight the relationship between technology, society and innovation.

Table 12.1 Future trajectories of the firms from the lens of Bricolage theory

Case	Penurious environment	Bricolage	Bricolage domains	Parallel bricolage	Selective bricolage
Mobile money	Affordability of financial services	Applying combinations at hand	Physical inputs	✓	
Eat Raja	Environmentally friendly cups	Applying combinations at hand	Skill inputs/labour inputs		✓
Mitticool	Affordable cooling devices	Seeking for standards	Skill inputs/market		✓
Padman	Lack of hygienicsanitary products	Making by doing	Physical inputs/skills/labour		✓
Asu machine	Optimising weaving process	Seeking for standards	Skill inputs/market/labour input		✓

The case study on mobile money illustrates the penurious environment is the affordability of secure financial services. Mobile penetration is close to 90% in India and connects the remotest corners of the country. The innovators tapped on this high percentage of mobile users and helped banks to get attached to mobiles so that the services become affordable and accessible to every individual. The bricolage domain is the physical inputs as the mobile phones got a new use of transacting money.

Traditional financial institutions transfer the service cost to the consumers as cost-to-use and hence the formal financial products and services are costly. For example, the financial services providers disguise these costs in several forms such as commissions on transactions, minimum closing balance, message service charges, account maintenance fees and inter-bank transfer charges. Process of account opening, onboarding and operation is still seen as cumbersome by many intending and unserved customers. Addressing the Society 5.0 value of "knowledge intensive society", through mobile money, financial services are brought near to the customers through mobile money agents who serve as intermediaries between customers and financial service providers thus reducing the cost of transactions and value addition. Since mobile money is utilised in the same form in various domains there exists community of practice of bricolage. The mobile money's potential of financial inclusion fulfils one of the objectives of Society 5.0 that greatly integrates cyber and physical space centred on human with the aim of addressing social problems along with economic advancement (Cabinet Office, Japan 2021).

EatRaja proprietor found severe environmental consequences of using single-grade plastic and the glaring amount of plastic and paper waste generated in this firm on a daily basis. He then engineered applying combinations at hand and converted the fruit shell as a cup for serving fruit juices. He also engineered the bicycle mixie where the usage of electricity is also minimal making their firm carbon neutral. The bricolage domains that were touched upon are skill inputs as the innovator himself worked on his skills to come up with an innovative service.

When a society's work and accompanying institutional arrangements meet a broad range of human requirements, it is said to be sustainable (Littig and Griessler 2005). Jugaad is a procedure in which the demands of society's citizens are prioritised in order to tackle some important societal issues. Each of the examples above demonstrates the societal benefits of jugaad and how they address the concept of sustainability in their own unique way. The example of EatRaja shows the positive societal consequences of jugaad innovations as well as their potential to meet some important societal demands. This initiative helps in reducing greenhouse gas emissions and promotion of sustainable industrialization which is one of the important objectives of society 5.0. Furthermore, since the customers were also involved in the making of the products for EatRaja, the bricolage comes under labour inputs. The organisation though created innovative products in the food segments the firm is contemporary and novel in introducing their products in a new way, and hence follows selective bricolage.

The third case of Mitticool faced a challenge to ensure accessible and affordable cooling equipment for bottom of the pyramid. Having expertise in working with clay he set to develop a fridge by following standards and ensure the quality of eatables

does not get deteriorated. He used his skill to devise an entirely new product and add to a new market and customer segment.

Jugaad, although may not address all resource constraints, deploying novel materials to address specific resource constraints is becoming a common practice. The Society 5.0 value of accumulating and sharing knowledge is demonstrated through Mitticool. Extrapolating existing knowledge, the technology complexities and unnecessary luxuries are reduced by using technology in the innovations without which the delivery of latent need goods of a refrigerator is made affordable. Further, most Jugaad are a result of a challenge arising from resource-constrained ecosystems. We see this demonstrated in Mitticool. The innovator then went to develop cookers, tawa and other kitchen utensils keeping the core as clay products, thereby it comes in the category of selective bricolage.

The fourth case of Padman faced a social issue of addressing the taboo of mensuration. The people lacked awareness and also the need for sanitary products. The innovator addressed the solution by speaking to women from the cities and also learnt how a sanitary pad would look like and how one could make it affordable to rural women folk. He thereby innovated by doing and made use of physical inputs, his skills and labour inputs.

Jugaad is a simple solution with a clever and improvised fix as the result of human intelligence and may or may not have the similar sophistication of a typical innovation. In other words, Jugaad is the art of generating solutions to life problems through improvisation despite scarcity of resources. It strips products or services of high costs and features through the process of value innovation. Jugaad involves rethinking the production processes and business models along with re-designing. The bottom of the pyramid customer segments are characterised with low-income, low educational status, and detachment from the formal economy apart from middle-class sections.

Jugaad innovations help in serving those customer segments profitably and sustainably which are constraints to businesses. Padman is one such example. Since the firm is focusing only on sanitary hygiene, it preserves the ability to leverage the unique services created through bricolage to generate growth.

The last case is of the Asu Machine which optimises the initial processing of the Asu for faster weaving process. The innovator faced a situation to simplify the hard physical work the women folk had to put up with to weave a silk sari. He tried understanding the standards required for the initial processing for developing appropriate standards for weaving. Further, he put in good use of his skills, getting feedback from the women on the working of the Asu machine as well as the markets, since the market was not introduced with any product of this kind the customer buy in was very crucial. Further since the innovator worked only on this innovation and leverages the innovation for growth, it comes under selective bricolage.

The jugaad innovations exploit these institutional voids to create social values compared to their developed counterparts. The Asu machine demonstrates the Society 5.0 value of people-centric society. This Jugaad is a feasible alternative compared to traditional institutions in serving the underprivileged market segments profitably and sustainably. Because the technological requirements of products and services are

easily accessible, affordable and deliverable through the intermediaries of consumers and service providers. Jugaad thus enables inclusive participation in the ecosystem where traditional innovation systems are weak or absent in efficiently serving the underserved and excluded market segments. The case of Asu machine is one such example.

In summary, Jugaad addresses four key constraints. The first constraint refers to affordability as it relates to the pricing of products and services. The second constraint refers to lack of adequate resources for ease of access, widespread adoption, and opportunity for growth. The third constraint refers to lack of institutions to promote and support growth of developing and underdeveloped economies through jugaad innovations. And the fourth constraint is the lack of sustainable living and making reasonable use of resources.

Although these simple and effective innovations such as EatRaja, Mitticool, Padman and Asu Machine not necessarily involve big data and AI but addresses critical social problems with minimum possible resources and contributes towards society 5.0. The diverse gaps are eliminated through new value created by innovation in Society 5.0 and enable the provision of customised products and services based on diverse individual needs. This helps solving social problems and promotes economic development in the society (Cabinet Office 2021).

Among several efforts towards driving jugaad innovations, the bricolage theory provides some idea of the different ways Jugaad innovation progresses. Jugaad is the art of generating solutions to life problems through improvisation despite scarcity of resources. It requires re-designing products and services that are readily accessible, easy to use and affordable in re-innovating products and services customised to the bottom of the pyramid segments. Sammut-Bonnici and McGee take the concept of economies of substitution in explaining the jugaad aptly. Jugaad works best when the cost of substituting older ways with newer, low-cost accessible products, is substantially low. Hence, jugaad as a business model innovation considers the local needs and situations in serving customers sustainably and profitably to develop adaptive technology in uncertainty.

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Chapter 13
Towards a People-Centered, Technology-Driven Society

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Abstract The chapters summarized in this book revolve around a "people" centered approach connected to a technology-driven society. This chapter presents key challenges, lessons learned, and recommendations for combining Society 5.0 and digital transformation to create resilient communities. It is a well-known theory that disaster risk is "vulnerable" to "hazards" themselves, such as earthquakes and floods, and can be mitigated by strengthening "coping capacities" against them. Even though disasters are inevitable, risk reduction requires knowing people's vulnerabilities and improving their coping skills. Japan's current situation in recent years and its "vulnerability" to ICT and data within the information society (1) the daily flux of people due to migration and work within the country and increasing population density in certain pockets; (2) the declining human capacity to cope with environmental changes and natural disasters due to low birthrates, aging populations, and diluted community networks; (3) reliance on technological rather than social solutions; (4) different digital divide at the level, and (5) unconscious overlooking of potential risks.

Keywords People-centered · Technology-driven society · Human security · Care

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13.1 Human Security and Well-Being for DRR

Based on lessons learned in the past and knowledge gained in the field, nurses, lawyers, and livelihood support workers have long been involved in this project. Individuals, families, and communities have been trying to solve problems through volunteer activities for self-help and mutual aid. On other hand, care needs are intangible from the outside. Emergency care support is mainly unofficial, unpaid, and burdensome. In health care, front-line health care providers, including hospitals, homes, and community health nurses, see the situation but cannot afford to have a say in providing rapid health crisis management and care. In addition, limited data sharing among agencies has led to interoperability problems and information gaps. The reality of past disasters was that, in a chaotic situation where both external support and media coverage of the disaster have been drastically reduced, local health care workers, professionals, and other volunteers are unable to help.

Research and development are underway to establish the technology and information infrastructure for the daily use of diverse data. To begin with, vulnerable communities are constantly offline due to unstable Internet connections, lack of access to Internet-enabled devices, and Internet capacity issues. Therefore, both offline and online tools are needed.

In Japan, vulnerable groups such as the elderly, people with disabilities, and foreigners are considered "disaster-sensitive." Local communities are supposed to support them by creating lists and individual plans. Particular vulnerability is an agnostic structure that cannot be objectified in life issues. In the long run, caring itself is necessary to support people's continued exploratory decision-making and strengthen their ability to "live" (Kanbara and Shaw 2022a). In addition to personal health care, people familiar with the community should "watch over" and "care for" people using local language and insights. However, the reality is that in a chaotic situation where both external support and media coverage of disasters are drastically reduced, local health care workers and professional volunteers are dealing with individual life issues through communication with residents (Kanbara and Susa 2013). The current situation is that there is no understanding of or response to people's diverse needs and problems that should be considered socially, or there is no connection to channels for receiving response or support. People are not aware of the risks and are disconnected from the continuity of their lives (Okamoto 2018).

COVID-19 made people experience self-isolation and restraint. Ethical perspectives such as the people's dignity and autonomy have been ignored in an environment that distances people from each other. It has become clear that comprehensive care support is essential to protect people's peace and dignity. Much will be lost in the future if people are not empowered with the preventive health care technologies needed in the community. In addition, evidence-based medical treatment alone, like infection control in hospital medicine, will not protect people's health. It is understood worldwide that social and environmental pressures limit the effectiveness of treatments. These situations have prompted the need to add a social dimension to health, crisis management review of universal health coverage, and local and micro

human security. There is an urgent need for citizen involvement and empowerment for human security as the all-hazards approach.

There is a movement toward networking, in which residents solve problems through grassroots activities using technology to deliver the voices of those who cannot speak up and connect them to the broader society. Health crisis management in highly uncertain communities requires comprehensive knowledge, the practice of individual self-care, and social innovation through communication that changes people's values and behavior patterns.

In 2018, WHO (World Health Organization) established a comprehensive framework called Health Emergency and Disaster Risk Management (HEDRM) as a standard for people's health and well-being in health crisis management, including disasters and infectious diseases (WHO 2018). It calls for strengthening health systems where communities can be involved in planning and risk reduction actions as the responsibility of the social system, rather than a single vertical governmental measure. There is a sustained need to reduce the actual risks causing the situation rather than simply responding to them. To this end, it is important to have guidelines and frameworks for research ethics that enable the social institutional-level organization and interdisciplinary research on the use of personal information. For example in health, the system should be as conducive as possible to utilize information in the case of secondary use of data obtained in primary use for purposes such as research, drug discovery, public health and public policy, and services, and should be classified according to the following functions It will be necessary to define the nature of the regulation.

Next Generation Infrastructure Policy Institute (NFI 2022), as for the functions of secondary use, the following categorization is proposed.

(i) Planning of public health policy, etc.,.
(ii) Academic research in medicine, etc.
(iii) Development of pharmaceuticals and medical devices by pharmaceutical companies, etc.,
(iv) Healthcare services by private businesses, etc.

Regulation of access to medical data shall address the following elements:

(i) Purpose of use
(ii) Users
(iii) Form of information processing (unprocessed explicit information/pseudonymized processed information/anonymized processed information, statistical information)

On the other side, Nursing care on disaster risk reduction seemed to be difficult to standardize and academicize. But it is necessary to recognize the universality of science that is quite different from human life". The story's universality, of what perceptions led them to take this action, is essential to human life. The universality of disaster nursing includes feelings, humanity, community help, human warmth, weakness, and the inspiration of hope for life (Yanagida and Sakai 2006). In the field of nursing, interdisciplinary field research is often required, and there needs to be

a consensus on the "what" and "how" of research based on the intended outcomes, i.e., "where do we want to get the results"? There are many gaps between researchers and the community (or between "government officials" and "community members," "responder" and "survivors," and others with the knowledge that is important and worth knowing). That is the basis of community research, and we need to be carefully and humbly aware of it. For example, when discussing "better recovery," does it mean a year or a kilometer, the same for government officials as survivors? What criteria can we use to measure sufficient numbers and sizes? In order to reduce disaster risk, we need to understand the current state of global health and what is happening there. It is crucial to consider the causes of this situation and share them with people.

13.2 Key Messages

Table 13.1 below shows the key messages derived from each chapter in the book. The key emphasis is: community and people, technology and implementation, personalized choices, people-centered and achieving human security and well-being.

13.3 Postscript

This book is based on the basic principles of human security. It accompanies individuals, families, and communities to help them survive their way in disasters or near-disaster situations. Disaster risk reduction can be viewed as a livelihood model in this context. This chapter proposes that the approach should be implemented forward to well-being from a people-centered perspective in line with globalization and digital transformation. Followings are some essential points in the book that need to be addressed in the future. Here are a few postscripts for a futuristic and resilient world.

Figure 13.1 shows what words frequently appear in relation to each chapter and part of the book. Chapter 1 is initially written to explore what it takes to claim human-centeredness. Chapters 2, 3, and 4 are written to explore what it takes to make the Society 4.0 lessons learned are described, and it is clear that providing and sharing information has been a challenge. However, Part 3 was about the initiatives and budding research of young researchers, government officials and start-ups, and seemed to be concerned with DIGITAL, data and local. In the overseas case studies, "make and use" was seen in the context of social and government rather than a disaster.

Finally, in Chap. 4, the focus is on community, health, open, society, and digital, data, etc. as "needs."

The following concepts were considered important through these discussions.

Table 13.1 Key messages emerging from the chapters

Chapter 1	Japan aims to build a sustainable society for human security and well-being through the "Society 5.0" cyber-physical system
	Digital transformation is a concept that refers to efforts to transform social systems and organizational culture through the development of new products and services, new business models, and reforms to create new value through the use of digital technology and is not an end in itself; which is important to note
	People-centered DRR approach can be referred to as "nursing care" and "health promotion"
Chapter 2	The SFDRR needs science, technology, and globally
	A single hazard had developed DRR countermeasure
	In a complex risk landscape, codesign of the DRR plan implementation by a community is vital
	It needs to focus on guidance based on science and technology for decision-making than a completed solution package
Chapter 3	The all-hazards minimize the time required for recovery rather than consider countermeasures based on the type of disaster
	Disaster countermeasure requires decision-making in the face of uncertainty, which is the challenge of information, data, and communication systems
	The utilization of personal numbers could contribute various efficient solutions, though it needs to clear some political issues
Chapter 4	Processing information into usable one (even disaggregated data) is critical, as well as making the assessment form and getting the data in a disaster setting
	Long-term disaster risk reduction requires dynamic data and open data
	Lay-man method and adaptive technology are crucial and need to be changed side by side for inclusive communication
Chapter 5	Statistics and dynamic data, especially micro-geo data, have become more available to promote EBPM in Japan
	Society 5.0 does not mean only a smart city or digital twin but needs a "slow city" that tries to realize a truly diverse society
	The essential factors in promoting the smart city are "empathy and sharing" with citizens and public–private partnerships related to technologies and wisdom
Chapter 6	There are many types of people's lists before/after a disaster, and they are not connected to individuals. The system is not designed to identify individuals
	Altruism results from the pursuit of social use of health care data, like research based on public health and solidarity
	The use of personal information in the event of a disaster poses a major challenge, and the introduction of data altruism has the potential to address the challenge
Chapter 8	Digital transformation has three components–"data, process, and users." Data originally comes from science, defined as individual facts, statistics, or items of information, often numeric

(continued)

Table 13.1 (continued)

	Capacity development is a primary requirement of digital transformation for citizens to access disaster information. Also, user-friendly interfaces will help citizens to utilize the information. Data resources and GIS functions can help provide information for decision-making support. It needs to be connected, integrated, and selected among resources and functions
	Disaster risk literacy needs perception and behavior, like personal health management, to act when a slight discomfort is noticed. XR can provide a real sense of crisis, suggesting that it helps raise crisis awareness. Society 5.0 expected individuals to make appropriate decisions and take actions to minimize the damage
Chapter 9	Open governance is required for DRR to make the government more accessible to everyone
	Many cases of responses using open data show many challenges and possibilities
	"Citizen collaboration" model of emergency management has become essential for effective response to emergencies and the potential of a whole-of-society approach in DRR
Chapter 10	Open government initiatives in disaster management in the US revealed many benefits such as improvement of decision-making, communication with the citizen, and collaboration between governments
	Web 3.0 technologies have the potential to understand and categorize data, code data with similar characteristics, and retrieve crisis-specific data effectively
	Open government is a process and depends on putting it in place before a disaster occurs, including infrastructure and response exercises
Chapter 11	"Leadership," "science," and "cooperation" are three crucial factors in the Chinese model of COVID-19 control
	It is believed that the community is the closest to the residents and they can rely on the community to do everything for them even after COVID has been lifted
	The development of information technology and its penetration into society have led to a significant advance in advanced information technology using information technology in COVID-19
Chapter 12	Jugaad helps address social problems and blends seamlessly through improvisation despite the scarcity of resources
	Jugaad indulges in rapid prototyping through collaborating with customers to build product and service features instead of being pre-planned so that they could be available in a disaster
	Jugaad enables products and services to be customized based on diverse individual needs so that social problems and economic developments are customized to change society
Chapter 13	Human security and well-being with people-centered and community-driven approaches are essential in Society 5.0
	We need to focus on a trans-disciplinary approach that helps achieve open governance and develop a knowledge society
	Grassroots, process innovation, youth leadership, and entrepreneurship development are vital in achieving an innovation ecosystem

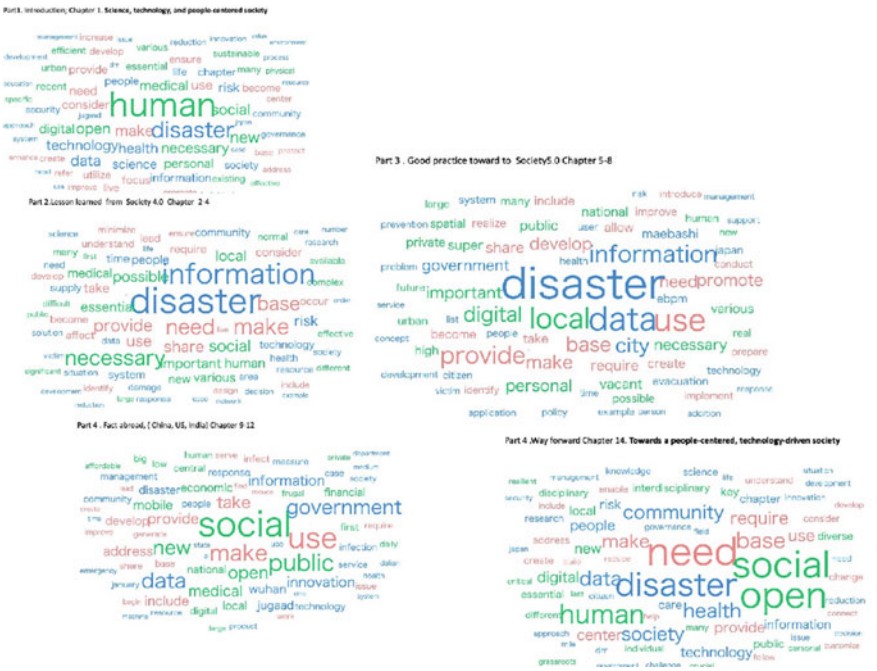

Fig. 13.1 Word cloud of this book by AI text mining (https://www.userlocal.jp/)

13.3.1 From Inter-Multi-Disciplinarity to Trans-Disciplinarity

Emergence, divergence, and convergence happen in a disciplinary evolution. Disaster risk reduction (DRR) as an emerging discipline has no exception. While it was dominated by science and technology 30 years back, the importance of a multi-disciplinary approach was aware strongly after the Great Hanshin-Awaji Earthquake of 1995.

Interdisciplinary relationships involve collaborating among contrasting disciplines or research methods to create new applications, analyses, or entirely new fields (Nicolescu 1997). What must be challenged and required now is that trans-disciplinary research as a new field that transcends the boundaries of disciplinary perspectives can be said to be a combination of interdisciplinary research and participatory approaches within a single framework. Figure 13.2 shows an example of trans-disciplinary flamework that was developed for Global Leadership Training Program in Disaster Nursing by the University of Kochi as mentioned in Chap. 4. The research paradigm requires non-academic participants as participants in the process of reaching a common goal, usually a solution to a society-wide problem. It can be seen as the culmination of an interdisciplinary effort. While interdisciplinary

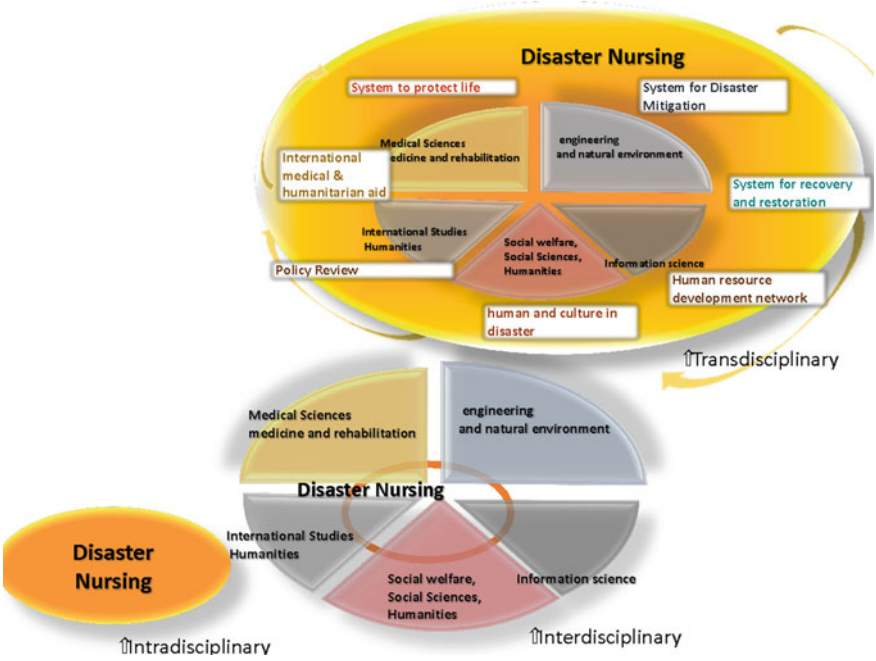

Fig. 13.2 Evolution of discipline from intra to trans-disciplinary in disaster nursing

collaboration creates new knowledge integrated from existing disciplines, interdisciplinary teams relate all disciplines into a coherent whole (McGregor 2004). Disaster policy and governance would play a critical role in a futuristic context. The importance of disaster nursing, community health, and public health need to be recognized in public policy and governance.

13.3.2 Knowledge Society

With the strong push from the Cabinet Office through Society 5.0, Japan is moving powerfully toward a knowledge society economically and culturally through the development of science, technology, and knowledge production. Society 5.0 is not a mere human versus non-human society, where AI (Artificial Intelligence) takes the key control. Instead, it focuses on an actual knowledge society deeply rooted in tradition, culture, values, and norms. It also respects the community's priorities and aspirations. The development of smart cities is not just technology or infrastructure-related issues, but it needs soft assets and value creation for a sustainable and resilient society (Wataya and Shaw 2019, 2022). A proper citizen-local government interface is required, ensuring transparency in the decision-making process.

13.3.3 Open Governance

Kanbara and Shaw (2022b) have pointed out the major challenges of open data and open governance in their recent analysis of the Atami landslide. While the need for open data and open science has existed for some time, the actual implementation is always challenging. The key challenge is the governance or regulatory one, not the social or technological ones. In contrast, the emerging technologies can be used at their best with an open innovation platform, where open data plays a critical role. This issue was demonstrated in the Atami case; prior open cloud data from the Shizuoka prefecture enabled emerging technology-based damage estimation within 5–6 h from the disaster. There is also a similar discussion on the challenges and potentials of data privacy against open data and open governance policy. Thus, appropriate open data and open governance policies are required at the national level to enable technology to grow and be helpful during, before, and after the disaster. The local governments can facilitate its implementation.

13.3.4 Grassroots and Process Innovation and Citizen Science

Mile zero needs to be at the community's core when we say people-centered society. We often use "last one mile connectivity" in the researcher's language. This expression is when we put the so-called "researchers" as mile zero and community to the last mile. There is often a mismatch between supply and demand or understanding of the community's needs and priorities in this process. Changing the "last one mile" to the "first one mile" allows us to understand and realize community needs and customize the solutions based on those needs and priorities. Indian example of *Jugaad* innovation is a problem-solving approach in a similar concept, where researchers or innovators provide improvised solutions. Citizen science is also crucial to enhance community engagement and ownership of the solutions. This concept is still underutilized in disaster risk reduction, while the environment or biodiversity field has effectively used citizen science. A combination of open governance, open innovation, an open data platform linked to citizen science, and grassroots innovation will be ideal for breaking the boundary in disaster risk reduction.

13.3.5 Youth Leadership

When thinking about the future of disaster risk reduction, it is essential to have the youth group involved in risk reduction. In the coming generations, especially those born between the mid-1990s and 2012, the Internet and digital devices have already existed since birth. They are digital natives and smartphone natives and

are moving toward the following trends. They often search for information online, primarily through social networking sites. Furthermore, they are used to sharing their thoughts and opinions on social networking sites and communicating openly and equally. This new generation does not fit into an environment where others force their views on them or make them hold back from expressing their own. They have a strong interest in social issues such as environmental destruction and racism. They are somewhat conservative toward careers, emphasizing the idea of time-effectiveness rather than cost-effectiveness. Not only that, but they tend to respect diverse values and perspectives. Therefore, young people are flexible in accepting differences from others, such as different races, sexual minorities, and people with disabilities. They consider an inclusive society to be desirable. The voices of this globally diverse group of young people must be reflected in future disaster management planning.

13.3.6 Sci-Preneurship *as a Newly Evolving Field*

DRR field needs not only technological innovation but social innovation. Several social issues in the communities can be addressed by building a new social entrepreneurship group through innovative approaches. Science-based social entrepreneurship or "*Sci-preneurship"* is the key to addressing community-based issues in DRR. As stated earlier in the chapter, "*Sci-preneurship"* is also linked to changing the last mile to the first mile. We need to provide a start-up ecosystem and incubation center linked to different academic institutions so that the students from an early stage can contribute to the social cause. In one of his recent remarks, Japanese Prime Minister Kishida defined the next growth area as "start-ups" rather than industries or business areas. He termed the year 2022 the "Year Zero of Start-up" to enhance the growth and expansion of start-ups. The Japanese government will set up a "Five-Year Start-up Plan" to make strong efforts to create start-ups, starting from 2022. Possibly this will provide new opportunities for the youth to challenge and apply their innovative ideas in disaster risk reduction.

13.4 Conclusion

The importance of human security and the provision of well-being for people and communities are at the core of Society 5.0. For DRR as well-being, we need to discuss what kind of "Co-implementation" should be provided by policies and measures and what kind of "community engagement" individuals should provide from a people-centered perspective. In this context, when disaster risk reduction is viewed from a livelihood model perspective, it has been critical for disaster science to support decision-making and consensus-building based on people's knowledge and actions from a "people-centered" perspective. The target of this book is to seek community resilience by raising the level of caring for the people and their surroundings, thereby

learning about the difficulties in life that will occur in the future, which will be completely different from those in the past, deciding on one's own actions, and building consensus. Using the idea described in this book, we can develop a tactical framework for communities, a place for knowledge exchange and co-creation of projects, and a model for activities that transcend administrative boundaries. The system generates data by integrating the wisdom and knowledge of local people and enables constructive discussions across disciplines that are expected to develop a consensus for a sustainable society.

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