

Great East Japan Earthquake Disaster in 2011: Lessons in Public Management

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Abstract. The Great East Japan Earthquake Disaster in March 2011, the unprecedented complex Disaster poses daunting challenges for the public management. The Disaster demonstrated only traditional public management cannot cope with all of these entangled issues in timely and appropriate manners. This paper articulated the associated consequences and challenges to draw lessons for the public management, and contribute to directing better public management for complex crisis and disasters which can be learned not only in Japan but also internationally.

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1. Introduction

The Great East Japan Earthquake Disaster (Tohoku Disaster) on March 11th 2011 embodied the interconnected interaction of mega-risks through the tripartite (earthquake, tsunami, and nuclear power plant disruptions) disaster. The unprecedented large-scale “complex” disaster caused not only human (approximately 16,000 death tolls and 3,300 missing) and physical but also social and economic impacts in short to long terms: Even more than one year after the Tohoku Disaster, the affected areas have tremendous social and economic problems, ranging from removal of tons of debris, shelter management, relocation to new residence areas, public health not only for radioactive concern over health but also psychological issues, to local economy (ex. fishery, agriculture, tourism) and unemployment issues. The indirect cost is estimated to be between 35 and 60 trillion yen (approximately US\$ 453 to 776 billion¹). More than that, the interconnected and interacted issues are linked with changing circumstances such as spread of radiation brought about tremendous uncertainties over society at different levels (see details in **2. Policy Problems**).

The above demonstrates that the Tohoku Disaster poses structural challenge to public policy and especially public management in that traditional ways of public management alone cannot cope with the challenge. What kinds of challenge came from the Tohoku Disaster from public management perspectives? Where are the gaps between the governmental response or efforts and better roles of public management? The paper aims at seeking answers for these questions by reviewing the Tohoku Disaster including both the response and recovery phases through case studies.

While the conventional wisdom is that local government should be at the focal point for addressing natural disasters, this paper focuses on the central government’s public management mainly because the size and impact of the Tohoku Disaster was far beyond the local capacity of disaster management: In the Tohoku Disaster, more than 14 city, town or village public buildings² were significantly destroyed including local “disaster management centers” and resulted in tremendous loss of human and disaster management resources. For example, Minami-Sanrikucho in Miyagi prefecture had to relocate to restart their operations, and the city building of Otsuchi-cho in Iwate prefecture was swept away by the tsunami and major city officials including its mayor were killed by the Disaster.

Thus, the size and impacts of the Disaster required the central government to play a central role in *managing* the Disaster. Furthermore, the Act on Special Measures Concerning Nuclear Emergency Preparedness in Japan (1999) states that the central

government will play a central role in the nuclear power disaster. On the other hand, it is noted that the “central role of the government” in this paper does not mean control by the government. Rather, the central role should be focused on management and coordination of information and other resources which are critical factors in addressing the unprecedented complex disaster as shown in the case studies in the following chapters.

To reach the goal of elucidating lessons learned from the Disaster through the lens of the nexus of complex disasters and public management, this paper takes the following steps. First of all, the paper will elaborate on the nexus of the “complex” disaster and public management to articulate policy problems (the structural problems), and provide an underlying conceptual background in reviewing the “complex” disaster. Then, the paper will review case studies of the Tohoku Disaster, focusing on how the government responded to the complex and interconnected mega risks and policy issues from public management perspectives. Thus, the paper will articulate what are gaps between the undertaken actions and the public management referring to the structural problems and the conceptual background. Finally, based on the review, the paper will attempt to contribute ideas for improving public management for complex disasters which can be learned not only in Japan but also internationally.

2. Policy Problems: Nexus of “Complex” Disaster and Public Management

What kinds of characteristics are structurally drawn from the Tohoku Disaster? How are those characteristics related to public management? What are the relevant policy problems? While the beginning of this paper has already indicated key aspects of the characteristics, the basic structural characteristics of the Disaster and the relevant key public management factors are delineated in each column, respectively in the Table 1.

Table 1: Characteristics of the Structural Challenge and the Relevant Key Public Management Factors

Characteristics of the Structural Challenge in the “Complex” Disaster	Key Public Management Factors to Adapt to the Structural Challenge
(1) Multi-dimensional (Human, physical, social and economic)	● Balanced and systemic approach considering the multi-dimensional impacts

impacts	
(2) Complex linked effects of interconnected and chained risks and linked effects on issues and sectors in short to long terms	<ul style="list-style-type: none"> ● Renewing specific public management to adapt to managing interconnected and chained risks and complex linked effects on issues and sectors. ● Resilience-based and balanced approach with pre-defined principles and institutions
(3)Uncertainties	<ul style="list-style-type: none"> ● Institutions to synthesize information, knowledge and experience throughout public management for actionable policies

Specifically regarding (2), the tripartite (earthquake, tsunami, and nuclear disruptions) mega risks in the Tohoku Disaster articulated vulnerabilities of interconnected and interacted risks and their significant impacts on policy issue/sector areas at multifaceted levels: For example, in the response phase, disruptions of power, phone and internet connections by the earthquake and tsunami severely impacted critical first response communications in areas such as nuclear disaster response and access to medical and food resources. In the recovery phase, as a consequence of interconnected risks, different policy issues/sectors became linked in chained and complex ways (ex. disaster -public health- trade- agriculture-fishery- production industries- employment) and uncertain manners.

The above consequences articulate the fact that public management must adapt to the structural challenge of the modern complex disasters. Possible pathways to this adaptation include providing a balanced and systemic approach and renewing specific public management focusing on a resilience-based (refer definition of resilience to 3. Conceptual Background) balanced approach with pre-defined principles and institutions. Especially to address the daunting challenge in (3) uncertainties generated as a consequence of (1) and (2), institutions must synthesize information, knowledge and experience throughout public management for actionable policies.

In fact, as an existing international standard guideline for disasters, the *Hyogo Framework for Action (HFA) for 2005-2015* has identified (1) the risk multiplying interaction of natural, human induced and technological hazards and their interaction with an ever more complex set of physical, social, and economic vulnerabilities, (2) the need to foster disaster resilience by introducing and integrating disaster risk reduction

into policy, planning and programs as a critical component of disaster management, and (3) the need for accelerating efforts to manage and reduce risk.

However, overall, disaster management experts and policy people are still struggling with *how* to manage and reduce those interconnected and chained risks and their impacts both at national and international levels. This is one of major policy problems in disaster management and public management needs to help overcome this challenge. In this context, the Tohoku Disaster provides a good case study to look for ways to overcome the challenge not only in Japan but also internationally.

3. Conceptual Background

The risk-based approach has recently become one of major methodologies for the public institutions. The risk-based approach commensurate the scale and magnitude of risks with four measures of risk management (Project Management Institute (2008)) is to avoid, transfer, mitigate and accept the identified risks. The more risks get unpredictable and complex, the more governments and international institutions tend to adopt the risk-based approach. For example, the Financial Action Task Force (FATF) adopted and recommended the risk-based approach to its member-governments (FATF (2012)).

Specifically, the inter-linked and chained risks in the complex social system have drawn keen attentions in different fields. The Eurasia Group, the New York-based analysis agency of geopolitical risks raised the full global convergence of political and economic risks as the top risk of the year 2012 in their report (Eurasia Group (2012)). Sugawara et al. (2012) stressed for post-disaster Japan to take the integral approach to view political and economic risks together. The World Economic Forum (2012) illustrated how the mega-risk of earthquake and tsunami as well as the nuclear accident in Fukushima was relayed to realization of operational, strategic and financial risks of global corporations (World Economic Forum (2012: 32)). Clapper (2012) underlined the multiplicity and inter-connectedness of the potential threats to the national security of the United States.

The multiple and inter-connected nature of risks require a fundamental change of ways of conventional approach for risks. The risks in the complex social system are so 'wicked' (Conklin (2005: 7-8)) that the analytic approach cannot solve a problem in risk management with the optimal design (Yasui (2011)). The fragmented agencies often ignore pre-warned risk as noise (Wohlstetter (1962)). This represents risk analysts' lack of knowledge on risk parameters (Vose (2000: 19)). Thus the uncoordinated and

mechanical responses by stove-piped agencies (Bazerman and Watkins (2004)) to disaster may cause tremendous failures in risk management (e.g., the response of US FEMA to the Hurricane Katrina (Lewis (2008))).

To pave a way for a fundamental change in public management, a systemic approach should be the focus. The systemic view plays a central role in business continuity plan of global corporations. The International Standard Organization (2012) is proposing to incorporate the concept of Business Continuity Management System (BCMS) within the ISO standard. The emergence of the BCMS indicates that the perplexed risk society (Beck (2009)) forced institutions and corporations in risk management to shift their focus on the systemic approach. The systemic approach can impact the organizational structure of a government in risk management, since the concept of regimes in risk regulation is related to some themes ‘notably in system theory and related fields of organizational and regulatory analysis’ (Hood et al. (2001: 11)).

One of key concept in the systemic approach is a holistic thinking of a social problem. Without considering interactions of inter-connected parts, a social problem cannot be solved (Nadler and Chandon (2004:7)). Another key concept is “resilience.” Resilience is defined as the systemic ‘approach to disaster avoidance, survival and recovery with expertise from a multitude of disciplines to an unprecedented degree’, and that is the opposite of brittleness (Jackson (2010:1, 12)). Jackson (2010:30) also noted that ‘resilience is an emergent property that cannot be deprived from its parts, only from the systemic approach’.

The United States and Australia are those of major countries which promotes a resilience-based approach in disaster management. Balboni et al. (2011) put operationalizing resilience as the center of their systems-based approach to mega-disaster. They articulate three pillars of resilience in the final report and recommendations of critical infrastructure resilience to the US federal government through the National Infrastructure Advisory Council (2009); 1) harmonizing and integrating the planning frameworks; 2) collaboratively developing and incentivizing the use of risk management practices; and 3) enhancing risk communications across the public and private sector at large. In Australia, the ministerial council for police and emergency management agreed on November 6, 2008 to launch the National Disaster Resilience Framework (NDRF). The NDRF is to be succeeded by the National Disaster Resilience Strategy (Rogers (2011)).

4. Case Study: Public Management in the Tohoku Disaster

This section reviews cases in Tohoku Disaster to identify how the government responded to the complex and interconnected mega risks and linked policy issues. Based on the review, the section will articulate what are gaps between the undertaken actions and the public management referring to the characteristics of structural challenge specified in the Section 2 and the conceptual background specified in the Section 3 (called “required actions in public management” hereinafter).

The following addresses five cases for major issues for the complex disaster, mainly covering response and recovery phases. Each case concisely elucidates 1) specific issue, 2) major experiences and governmental actions undertaken for each issue, and 3) gaps between the undertaken actions and required actions in public management.

Case 1: Disaster Response Organizations and Professionals

Issue: The significant impacts of Earthquake, Tsunami and nuclear disruptions require multi-faceted and skillful management/coordination of different disaster response organizations and stakeholders quickly and effectively.

Experiences/Actions Undertaken in the Response:

To respond to the Tohoku Disaster, the Prime Minister’s office has established more than 20 new offices or committees with different heads of leaders and members after the disaster through March to April 2011. The list of major established or committees or offices is shown in the Table 2.

Table 2: New Committees or Offices Established in Response Phase

Earthquake/ Tsunami	Emergency Disaster Response Headquarter
	Special Response Headquarter to Support Victims
	Response Working Team to Secure Safety and Relief in Devastated Areas
Nuclear Disaster	Nuclear Disaster Response Headquarter
	Nuclear Disaster Victim Life Support Team
	Fukushima Nuclear Plant Incident Response Integration Headquarter

	Headquarter for Response to Economic Impacts by Nuclear Power Plant Incidents
	Office for Response to Economic Impacts by Nuclear Power Plant Incidents
	Headquarter for Power Demand and Supply Emergency Response
Designs of Reconstruction	Reconstruction Headquarter
	Reconstruction Design Council
	Working Group for Reconstruction Design

On the other hand, regarding specific activities of the above organizations, Vice Prime Minister, Katuya Okada reported to a ministerial meeting on 27th January 2012, more than 10 months after the Disaster, that 10 out of 15 organizations did not make notes or records. As for the reason, he stated that it is likely members of the organizations were too busy to record. Thus, the specific activities are not clear and cannot be tracked in terms of what kinds of roles they played, what kinds of matters were discussed and what kind of process they made for decision makings.

Given the above, implications or linked effects of these newly established offices/ committees during the response phase are drawn:

- Although different government disaster management-related organizations such as the ones within the Cabinet Secretariat or the Cabinet Office for the Disaster Management have been officially established for a long years, those organizations did not play a central role during the response phase. For example, the Disaster Countermeasures Basic Act stipulates the Minister of State for Disaster Management is in charge of administrative matters related to disaster prevention, disaster response measures, and basic policies regarding disaster response and disaster recovery (Art 11.5.). However, the Minister of State for Disaster Management within the Cabinet Office resulted in playing a minor role during/after the Disaster.
- Moreover, there is a wealth of skilled disaster response professionals in Japan, these professionals were not integrated and incorporated well into the coordinating mechanism of public management in disaster management during the disaster.
- As a result, the ad-hoc organizations led to ad-hoc disaster management operations. Because they are not founded on the well-understood mechanisms, their roles, process and functions were unclear within the organizations or among organizations, which confused not only the public but also the practitioners and disaster

management officials.

Gaps: Pre-disaster management such as the ones within Cabinet Office or Cabinet Secretariat is not linked to operations in post disaster management. Few formal well-understood mechanisms exist for coordinating multi-faceted operations during disaster response. As a result, a balanced and systemic approach considering the multi-dimensional impacts of the Disaster was hardly seen.

Case 2: Critical Information and Data for Affected People and Policy Actions

Issue: Critical information to impact life and safety for affected people at devastated areas is required to be disseminated as quickly as possible through appropriate process and manners. Likewise, critical data which impact policy decisions should be relayed to decision makers as quickly as possible in appropriate process and manners so that the data is utilized to make the best decisions at the crisis.

Experiences/Actions Undertaken in the Response:

During the response to the Tohoku Disaster, particularly central coordination and distribution of critical information, from the national level to the local level, has proven to have been largely dysfunctional.

For example, in Minami-Soma city in Fukushima prefecture people were confined to their homes because of the crippled power plants, there was a significant shortage of foods, water, medical supplies and gasoline. Mayor Katsunobu Sakurai claimed through news media that even weeks after the Disaster the city has not had any contact with or received any information directly from the central government, including the status at the crippled power plant, and he had to depend on several news media reports. This is not the only case, but many similar cases were heard from local mayors including Namie-cho, Fukusima Prefecture. Mayor Tamotsu Baba, as a witness of a public meeting in National Diet of Japan, Fukushima Nuclear Accident Independent Investigation Commission on 21st April 2012, emphasized he did not receive any information from the Government

Regarding critical data, the most typical case was seen in the national government's mishandling with radiation forecasts from the computer system known as the System for Prediction of Environmental Emergency Dose Information (SPEEDI). Although SPEEDI provided data on radioactive releases from the Fukushima Daiichi

nuclear plant during the continuing disaster, the data has not been communicated appropriately within the central government.

More specifically, a direct communication channel did not exist to link SPEEDI based information and analysis to the Prime Minister who served as the directors general of the nuclear emergency response headquarter. The result of this lack of communication was that after the news media reported the dysfunction of communication on data from SPEEDI, the official governments ended up with blaming each other:

For example, one of the regulators for the nuclear plants, the Nuclear and Industrial Safety Agency under Ministry of Economy, Trade and Industry had to follow order from the Prime Minister's office without knowing how they reached their decision (in fact the government had resorted to just drawing rings around the plant for evacuating everyone within a radius) . Then-Prime Minister, Naoto Kan explained that he did not receive any report regarding SPEEDI from the head of the Nuclear and Industry Safety Agency although he sat in front of the Prime Minister when he made a decision on evacuation locations. Also,, another regulator noted that although the office of the Nuclear Safety Commission, under the Prime Minister's Cabinet Office, had received the SPEEDI data hourly from the Education Ministry since the first hours after the catastrophic earthquake and tsunami, the Commission's office thought the same data has been sent to the Prime Ministry's office and simply had not taken any action from them.. However, there were no direct reporting lines for passing the data from the Education Ministry to the Prime Minister's Office for SPEEDI.

Gaps: The above case demonstrates pre-defined principles and institutions to make sure appropriate process and manners in disseminating critical information or relaying data to decision-makers are missing or are not implemented.

Case 3: Risks of Interconnected Critical Infrastructures

Issue: Since the critical infrastructures are interconnected in complex ways in modern societies, one disruption of critical infrastructures may lead to disruptions of other critical infrastructures which prevent functions of disaster management. It is critical to articulate the dependencies of critical infrastructures before the Disaster and find out the how to minimize the risks of disruptions and how to address the issues by constructing coordination schemes for different stakeholders at the public and private sectors to address these problems beyond geographic regions and expertises..

Experiences/Actions Undertaken in the Response: Reviewing the Tohoku Disaster, two major relevant experiences are articulated:

- Immediately after the disaster, because a major airport in Sendai city in Miyagi prefecture and other public transportations such as train were severely damaged, the devastated areas can be accessed only by cars. In that situation, local municipal officers and volunteers in the private sector at different locations nationwide attempted to deliver foods/waters and other critical commodities by tracks and cars. However, because of the shortage of gasoline at local gasoline stations, smooth delivery of goods has been suspended which led to food and water shortage at the devastated areas.
- Disruptions of power, phone and internet connections caused by the earthquake and tsunami severely impacted critical communications between national to local governments or between governments to first responders at the affected nuclear power sites or medical sites at the devastated areas. The disruption of communications has led to different confusions in critical information dissemination and delays in appropriate response to urgent matters.

During the response phase, although stakeholders at different sectors such as communications and IT worked very hard in recovering individual critical infrastructures, there were very few specific coordinated actions by the public sector to address those disruptions of critical infrastructures partly because few mechanisms exist for coordinating stakeholders which should have been addressed before the Disaster.

On the other hand, some good practices were seen in the coordination at the local and the private sector level. For example, commercial helicopter pilots across Japan recognized the delay in government-ordered deliveries of food, water, medicines and supplies. Through the private Helicopter Conference of Japan (HCJ), pilots collected donations to cover its fuel costs and used helicopters based in Miyagi to distribute supplies to shelters in the area. The pilots also identified other communities with severe water shortages, some of them having to boil and filter pool water for drinking. By June 2011, the HCJ had completed over 300 missions, delivering more than 40 tons of supplies.³

Another example is that the Tono City in Iwate Prefecture, has paid specific attention to Tono's unique location an hour away from the Pacific Ocean coast, and initiated and promoted the coordination of logistical support to prepare for earthquakes for nearby coastal cities in northeastern Honshu since 2007. As a result, immediately

after the Disaster, the Tono City and an nonprofit organization known as the Tono-Magokoro Network played a critical role in acting as a focal point to coordinate logistics for response and recovery efforts in devastated coastal regions nearby. The city collected and delivered more than 250 shipments of food and commodities from different cities to the region during the response phase.⁴

Gaps: As indicated in the above, currently few specific mechanisms exist in coordinating actions for risks of interconnected critical infrastructures by the public sector. Although some experts understand the risks of interconnected infrastructures, the public sector tends to address individual problems within individual sectors or section levels, and few pay attention to coordinating efforts during disasters.

Given the above, it is critical to renew the existing public management for these issues and construct ways in managing the relevant interconnected and chained risks and complex linked effects on issues and sectors. The way should be focused on pre-disaster coordinating mechanisms with resilience-based and pre-defined principles beyond geographical and expertise borders. The ways may be possible by linking good practices within local communities and the private sectors indicated in the above.

Case 4: Management of Affected Broad Social and Economic Dimensions

Issue: After the complex disaster, it is essential to address the full spectrum of disaster recovery issues focusing on both social and economic dimensions, including shelter management, community rebuilding, public health, employment and local and national economy.

Experiences/Actions Undertaken in the Response:

As of the end of May 2012, more than 14 months after the Disaster, the local devastated areas in the Miyagi, Fukushima, and Inwate prefectures still have tremendous social and economic problems. Those problems range from removal of tons of debris, shelter management, relocation to new residence areas, public health not only for radioactive concern over health but also psychological issues (such as posttraumatic stress disorder (PTSD), to local economy and unemployment issues. Especially since the economy of local areas depend on fishery, agriculture and tourims, speeding up recovery to rebuild the devastated sites is an urgent matter. Specificaly the unemployment rate are very high: Although there is no official statistics, it is roughly estimated more than 120,000

people in the areas are in the unemployment.

The above current situations reflect the slow and fragmented actions of the government: In fact, the Act on Reconstruction in Response to the Great East Japan Earthquake was passed on May 24th 2011 which states the Reconstruction Headquarters shall be set up to undertake the 1)planning, drafting and overall coordination of the Basic Guidelines for Reconstruction in response to the Great East Japan Earthquake. 2) promotion of national support for reconstruction projects conducted by concerned local governments, promotion of other reconstruction measures implemented by other concerned administrative agencies and overall coordination of such projects and measures (Article 12). However, the Reconstruction Headquarters, which is called Reconstruction Agency afterwards, was officially set up on February 10th 2012, that is, eleven months after the Tohoku Disaster. Before setting up the Agency, different ministries have addressed different cases and issues differently.

Gaps: Although it is too early to evaluate roles and activities of the Reconstruction Agency, at least Japan should have had this kind of institution much earlier. Especially given the above interconnected and complex linked effects on issues and sectors in the devastated areas, it is critical to have a central coordination-focused institution which can make commitment in managing issues and projects systematically and holistically.

Case 5: Review and Update

Issues: Since the Tohoku disaster is not only case for complex disaster and we are uncertain in terms of when different disasters are coming and what kinds of impacts they bring, it is critical to have a systemic (holistic and resilience-based) approach to prepare for any kind of disaster. For this, it is essential to review the whole process of the disaster management during the Disaster, draw the lessons based on the review and update the public management for better disaster management. The review should include the third party to keep independency and objectiveness and all of the review process should be open to the public. Also it is important to have an open mechanism to track how the lessons are incorporated in renewing the public management to make sure the public recognize better disaster management for future events.

Experiences/Actions Undertaken in the Response:

While individual government ministries have started their own reviews within their

institutions, there are few institutions or mechanisms which have undertaken independent evaluation of the disaster management in the Tohoku Disaster yet. On the other hand, in terms of an independent review, it is to note that the National Diet established the National Diet Japan Fukushima Nuclear Accident Independent Commission (NIIC), which is the independent investigative commission for the Fukushima Nuclear accident on December 8th 2011. The NIIC is the first one in Japan's constitutional history as an independent investigative body established by the National Diet.

According to the legal stipulates in the Law for the National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission, the chairman and Commission members (nine) were appointed by Speakers of House of Councilors and House of Representatives and were selected outside from the private sector. The commission conducts its investigation of government based on investigative powers (Article 15), insulated itself from the political influence of political parties and Diet members. Also, the Commission sets a goal of about six months from the date of appointment to submit to the Speakers of House of Councilors/ House of Representatives a report listing the accident investigation results and proposals, and to publish it. (Article 16).

Gaps: Although the NIIC was established almost nine months after the Disaster, it is a good starting point to have such an independent review body for better nuclear disaster management for the future. On the other hand, Japan needs more independent review bodies not only for the nuclear power disaster but the whole process of the Tohoku Disaster. Especially, the complex and uncertain disaster requires mechanisms to synthesize information, knowledge and experience systematically throughout public management for better disaster management.

5. Conclusions and Policy Implications: Lessons Learned and Toward Resilience-Based Public Management

The Tohoku Disaster highlighted the traditional public management has prevented effective disaster management in different ways. The stove-piped and non-holistic approach led to ad-hoc and fragmented response to interconnected and chained risks.

To overcome challenges Japan faced during the response and recovery phases, the existing public management needs to be reviewed to incorporate more systemic (holistic and resilience-based) approach to adapt to large-scale and complex disaster risks.

Especially, the conventional way of fragmented and ill-coordinated approach lacks in the resilience capability in allocating resources in appropriate and timely manners.

More specifically, to close the existing gaps in public management drawn from the Tohoku Disaster, the followings are pointed out:

- Formal well-understood mechanisms for coordinating multi-faceted operations are essential. Especially, a balanced and systemic approach considering the multi-dimensional impacts of the Disaster is necessary.
- Pre-defined principles and institutions to make sure appropriate process and manners in disseminating critical information or relaying data to decision-makers needs to be articulated before disasters.
- It is urgent to set up pre-disaster coordinating mechanisms for different critical infrastructure sectors with resilience-based and pre-defined principles beyond geographical and expertise borders. The ways may be possible by linking good practices within local communities and the private sectors.
- It is critical to have an central coordination-focused institution which can make commitment in managing post-disaster issues and projects systematically and holistically.
- The complex and uncertain disaster requires independent multi-layered mechanisms to synthesize information, knowledge and experience systematically throughout public management.

Finally, the authors provide three policy implications based on the above discussions.

- Public management in disaster management for complex and uncertain disaster risks should be focused on holistic and resilience-based approach to provide well-balanced policy instruments of disaster avoidance and survival and recovery.
- Preparedness and readiness to complex and uncertain disaster risks should be addressed with the *ex-ante* coordinated information and response hub institutions by incorporating different stakeholders and experts into the policy formation system for disasters, not by *ex-post* and *ad hoc* institutions.
- The *ex-ante* coordinated institutions should be systematically built from a long-term perspective with constructive cooperative mechanisms of various layers of governments, the private sector and civil society organizations. Thus, we will be better prepared for complex and uncertain risks effectively in the

modern risk society.

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Footnotes

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