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Paper:

National Crisis and Resilience Planning
– How to Measure Huge and Compound Disaster that Causes National Crisis –

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In the last two decades, three great earthquakes have occurred in Japan: the Hanshin-Awaji earthquake of 1995, the Mid-Niigata earthquake of 2004, and the East Japan Earthquake of 2011. After the East Japan earthquake, a devastating tsunami caused significant casualties and home destruction. More than 18,500 people were killed and more than 121,000 homes were destroyed. In addition, the tsunami destroyed nuclear power stations, which resulted in a severe crisis not previously experienced in Japan.

On the other hand, earthquake disasters on a huge scale have been announced to occur as probability of about 70% in the next three decades. One such earthquake is Tokyo inland earthquake that destroys 610,000 homes and kills 23,000 people, and the other is the Nankai Trough earthquake that destroys 2,380,000 homes and kills 320,000 people. In addition, compound disasters where one disaster merges with another disaster may cause damage on a mega scale in this century.

In order to address these mega disasters, it is very important to make efforts to reduce damage in the pre-disaster period. According to local plans for national resilience, each municipality must make efforts to reduce level of damage which is able to response trough a Business Continuity Plan (BCP). In addition, each municipality must implement long-term urban projects with a vision toward reconstruction after a mega disaster trough a pre-disaster recovery and reconstruction plan. It is necessary to make revolutionary efforts rather than standard disaster management efforts to reduce damages in the pre-disaster period.

Keywords: National crisis, Compound disaster, Earthquake, Tsunami, Pre-disaster recovery, National Resilience Plan, Business Continuity Plan

1. Prologue

In 1995, the Southern Hyogo earthquake caused the great Hanshin-Awaji earthquake disaster in and around the current Japanese metropolitan area of Kobe. More than 1,200,000 homes collapsed and burned and 5,500 people were killed. Various urban facilities such the Shinkansen railway, other railways, subways, urban highways, high rise buildings, and service systems for power, gas, water and communication were destroyed. This was the greatest disaster is the great disaster since the Ise-wan typhoon disaster of 1959, in which more than 5,000 people were killed. Since that time, it has been said that the 21st century would be a century of huge disasters in Japan, in contrast to a relatively calm latter half of the 20th century.

Since 2000, earthquake disasters have occurred almost every year, and several typhoons have come to Japan. For example, the Tohoku Pacific offshore earthquake, with a magnitude of 9.0, occurred along with a severe tsunami n March, 2011. This great earthquake shook the Eastern half of Japan from Hokkaido to the Tokyo Metropolitan region. A the maximum Japanese seismic intensity of 7 degrees was recorded in Kurihara City near Sendai City and although damage to buildings was not severe damage was sustained throughout a large area. More than 270,000 homes were nearly destroyed and, approximately 120,000 homes destroyed by the tsunami. Approximately 15,000 people of them were killed and missed by the tsunami, although more than 18,500 people were killed and missing totally. The scale of this disaster was not under-assumption but over-assumption. However, it was not considered the scale of a national crisis.

The intensity of the disaster is not measured on the scale of damage but the ratio of damage. From this point, the indicator of the intensity of a disaster is defined by the ratio of the number of people killed to one million of the national population on each historical devastating disaster. In the history of disasters in Japan, we can find disasters more severe than the East Japan earthquake. According to **Table 1**, although the ratio of the Hanshin-Awaji earthquake is 43 and that of the East Japan earthquake is 146, we found six disasters with a ratio of more than 200. These include two earthquakes and tsunamis in the 17th century, three earthquakes and tsunamis in the 19th century, and one earthquake in the 20th century. The most recent of these disasters was the Kanto earthquake in 1923 that caused conflagrations in Tokyo and Yokohama. Approximately 70,000 people of 105,000 people who killed were caused by these urban fires. The collapse of houses killed 35,000 people primarily in Kanagawa prefecture, where was shaken severely upon the hypocenter. During

Table 1. Devastating and compound disasters experienced throughout Japanese history and those with potential to occur in the near future.

Name of Disaster	Year	A: National Population (million)	B: Number of victims (person)	Victim ratio A/B (persons per million)	Note
Jogan Sanriku tsunami[1)]	869	6	1,000	167	Nihon trench
Nankai earthquake[2)]	887	6	many	–	Nankai trough
Keityo Tokai & Tonankai earthquake[2)]	1605	12	2,500	208	Nankai trough
Keityo Sanriku tsunami[1)]	1611	12	6,800	567	Nihon trench
Genroku Kanto earthquake	1703	28	5,200	186	Sagami trough
Hoei Tokai & Nankai erathquake[2)]	1707	28	4,900	175	Nankai trough
Ansei Tokai & Nankai earthquakes[3)]	1854	33	20,000	67	Nan-kai trough
Ansei Edo earthquake[4)]	1855	33	10,000	33	Inland quake.
Meiji Sanriku tsunami[1)]	1896	42	22.000	524	Nihon Trench
Kanto earthquake	1923	60	100,000	1667	Sagami trough
Syowa Sanriku tsunami	1933	68	3,100	46	Nihon Trench
Air bombing of World War II	1945	72	331,000	4597	115 burnt cities
Ise-wan typhoon	1959	94	5,100	51	
Hanshin-Awaji earthquake	1995	126	5,500	43	Inland quake
East Japan earthquake and tsunami	2011	127	18,600	146	Nihon trench
Tokyo Inland earthquake[5)]	?	120	23,000	192	Inland quake
Nankai Trough earthquake[6)]	?	120	323,000	2692	Nankai trough

A: Historical population until the 19th Century was estimated using the data from Syakai-kougaku kenkyujo (1972). Current population was estimated by the author from the National Censuses.
B: The number of victims was based on the Chronological Scientific Tables of 2015.
A/B: The victim ratio was calculated as the number of victims per one million people from the national population on each year.
1) A tsunami caused by an M.8 class earthquake that occurred near the Nihon trench repeatedly attacked the Sanriku region which is located in the Pacific Coast region of North-east Japan. Most of damage was caused by tsunami rather than the earthquake. The earthquake disaster in this region was thus attributed to a "tsunami" rather than "earthquake."
2) Great M.8 class earthquakes occurred repeatedly near the Nankai trough along the Pacific region of West Japan. The earthquake disaster in this region was attributed to an "earthquake," because the damage was caused not only by the tsunami but also by tremors throughout the region.
3) The M.8.4 Ansei Tokai earthquake occurred near the Eastern part of the Nankai trough on December 23, 1854. Thirtytwo hours later, the Ansei Nankai earthquake occurred in the Western part of the Nankai trough on December 24, 1854. The scale of damages increased broadly and significantly as a result of the earthquake. This is an example of a "compound disaster."
4) This earthquake with an estimated magnitude of M.7.07.1 occurred below the Center District of Edo in 1855, 10 months later. Almost all damage was caused by a tremor.
5) Central Disaster Management Council, Working Group for Measures for the Tokyo Inland Earthquake (2013a, b, c, d).
6) Central Disaster Management Council, Working Group for Measures for the Nankai Trough Earthquake (2013a, b, c, d).

that time, the national population was almost sixty million – half the present population – and the 70,000 people killed by conflagration reached more than 1 percentage of a national population. The ratio of the Kanto earthquake reached 1667 as eleven times of that of the East Japan earthquake disaster.

However, war is certainly more devastating than national disasters. During the World War II, 115 cities were burned from air bombings, including atomic bombs dropped in Hiroshima and Nagasaki. In total, more than 63,000 residential hectares and more than 2.3 million homes were burned, and 331,000 civilians were killed. The ratio here reached 4,597, one hundred times that of the Hanshin-Awaji earthquake.

In the 21st century, it has been said that we will experience earthquakes greater than those that we have experienced in the postWorld War II period, although members of Japanese society will be aging and population will decrease. In addition, not only will the scale of disaster grow, but compound disasters will also continue to occur. For example, if a great typhoon follows one week after a great earthquake or if multi great earthquakes occur, the scale of damage will increase more the damage from one disaster alone. After an earthquake that damages river banks and drainage systems, a rather small typhoon can cause significant damage by flooding.

In 21st century Japan, we must prepare for greater disasters and implement measures to reduce damage.

2. Five Years of East Japan Earthquake and Present Condition of Recovery Process

The East Japan earthquake is the fifth mega earthquake of magnitude 9.0 or greater that has occurred in the world. This earthquake shook Japan broadly but was not that strong. Almost all of the severe damages was caused by a huge, wide tsunami that struck coastal areas from Hachinohe City in Aomori prefecture to Asahi City in Chiba prefecture. The tsunami rose inland over banks in these coastal areas. In the three severely damaged prefectures of Iwate, Miyagi, and Fukushima, more than 40 local governments were severely damaged and were reconstruction plans.

In Fukushima prefecture, two nuclear power stations were struck by the tsunami and the first Fukushima Nuclear Power Station lost the electric power to control the atomic piles. These reactors were severely damaged and they collapsed and exploded. As a result, many local governments in the Northwest region of the nuclear power stations were polluted with radiation. The 11 polluted local governmental areas were designated as evacuation zones and all of the residents of these areas had to quickly evacuate to neighboring areas. A year later, approximately 60,000 people moved from Fukushima to the other prefectures. In March 2016, five years after the East Japan earthquake, more than 43,000 people continue to live in those outside prefectures.

In Iwate and Miyagi prefectures, a tsunami severely rushed the coastal areas. In the tsunami flood zones, everything was completely destroyed. All urban functions were extinguished in the flood zones and all of the buildings and homes collapsed as a result of the twometers high tsunami. In total, damage from the East Japan earthquake resulted in nearly a complete loss of 122,000 homes and 18,600 people. More than 80 percentage of these total loss and killed were caused by tsunami.

In the affected inland areas, approximately 260,000 homes were nearly destroyed by shaking and liquefaction. Especially in lowland, life line systems for water, gas, electric supplies, and tele-communication were halted for quite a long time due to liquefaction.

In the Tokyo metropolitan region, all of the high-rise buildings and especially super high-rise buildings more than 100 meters-high continued to tremble slowly and largely for eight minutes or more. All of the railways were stopped automatically for safety checks in 14:46 on Friday, when the earthquake occurred. During this time, many people left their homes. It is estimated that the two of thirds of residents in Tokyo metropolitan region left homes in an afternoon of the weekday. The number of total residents in Tokyo metropolis is thirty-five millions. More than five million people of trippers and commuters, including business men, laborers, students, and others were unable to return home, because every traffic service was stopped for the safety checks, those were continued in more than ten hours. Many people must stay in central area of Tokyo in that night.

In the five years since the earthquake, the coastal areas damaged by the tsunami and the areas polluted by radiation from the Fukushima Nuclear Power Station accident have not yet recovered. How has the recovery and reconstruction progressed in the last five years? An image of the movement of victims of the tsunami and the recovery and reconstruction process in the coastal areas damaged by the tsunami is shown in **Fig. 1**.

In the first year, each local government implemented quick-recovery measures involving the construction of evacuation shelters and temporary housing and the drafting of a recovery and reconstruction vision and plan. However, local governments were unable to promote re-

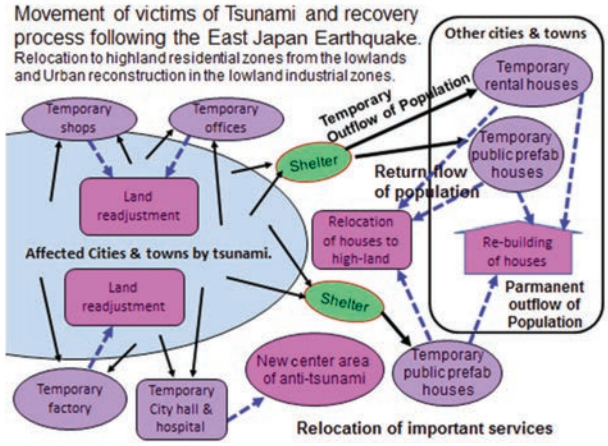


Fig. 1. Image of victim's movement and reconstruction process during the five years in Tsunami affected areas after the East Japan earthquake. (Nakabayashi 2014).

construction projects because the central government delayed to establish the schemes of recovery and reconstruction, reconstruction measures and a promotion system. In February of 2012, 11 months after the earthquake, a Reconstruction Agency was established and 40 measures for various recovery and reconstruction projects were established for local governments.

In the second year, every local government was following the Reconstruction Plans according to the reconstruction vision and the general and financial plans. In addition, they started to negotiate with landowners for the purchase of reconstruction site. As a result, land surveys and the other preparedness measures for reconstruction projects could not commence yet in the second year. These negotiations were not easy and required many months to complete. In spite of significant support from the local governments in every prefecture, few reconstruction projects for the development of new housing sites in the highlands and land reclamation and readjustment to industrial sites in the lowlands did not start until the third year.

In the fourth year, the basic projects such as the reconstruction of affected lowland areas and new development in the highlands commenced simultaneously. These basic construction projects continued into the fifth year, the last year of intensive reconstruction period. Significant amounts of mud were removed from the mountainside to the lowlands near the sea. Because the mud from the development of housing sites in the highlands was used as reclaiming material in lowlands, both basic reconstruction projects were implemented at the same time. Therefore, in these five years, industrial and business facilities were not fully rebuilt in the tsunamiaffected zones. This means there are few jobs available in the coastal areas. Many young people have moved to metropolitan region including Sendai city and neighboring cities to get jobs. They live in public housing or in private rent-free homes for victims of the natural disaster subsidized by the National Government through the Disaster Relief Law. However,

Table 2. Population trends in the five years after the tsunami following the East Japan earthquake in the affected coastal areas of Iwate, Miyagi, and Fukushima prefectures.

Number of areas by population trend			Tomioka town[1]	-100.0%	16,001 p.
+3.4～6.0%		3	Okuma town[1]	-100.0%	-11,515 p.
+0.0～3.3%		3	Futaba town[1]	-100.0%	-6,932 p.
−0.0～−2.5%		2	Namie town[1]	-100.0%	-20,905 p.
−2.6～−5.0%		6	Iioka Village[1]	-99.3%	-6,168 p.
−5.1～−7.5%		4	Kuzuo village[1]	-98.8%	-1,513 p.
−7.6～−10.0%		6	Naraha town[2]	-87.3%	-6,724 p.
−10.1～−15.0%		3	Onagawa city	-37.0%	3,717 p.
−20.1～−4.%		6	Minami-sanriku town	-29.0%	5,054 p.
−99.1～−100%		7	Kawauchi village[2]	-28.3%	-799 p.
Total of affected coastal areas		42	Yamamoto town	-26.3%	-4,390 p.
Number of population decrease		−156,182 p.	Ozuchi town	-23.2%	3,544 p.
Number of population increase		+50,041 p.	Hirono town[3]	-20.0%	-1,095 p.
Total number of population change		−106,141 p.	Minami-soma city[1]	-18.5%	-13,145 p.
Area of population increase, ratio and number			Rikuzen-takada city	-15.2%	3,543 p.
Rifu town	+5.6%	+1,887 p.	Yamada town	-15.0%	2,791 p.
Natori city	+4.9%	+3,585 p.	Kesen-numa city	-11.7%	8,572 p.
Sendai city	+3.5%	+36,199 p.	Noda village	- 10.9%	-505 p.
Iwaki city[3]	+2.1%	+7,095 p.	Tanohata villge	- 9.9%	-382 p.
Soma city[3]	+2.0%	+758 p.	Fudai village	- 9.5%	-292 p.
Iwanuma city	+1.2%	+517 p.	Iwaizumi town	- 8.9%	-965 p.
Area of population decrease, ratio and number			Shichigahama town	- 8.7%	-1,765 p.
Shinchi town[3]	- 0.0%	-4 p.	Ishinomaki city	- 8.5%	-13,590 p.
Tagajo city	- 1.5%	-932 p.	Higashi-matsushima city	- 7.9%	-3,385 p.
Kuji city	- 3.3%	-1,228 p.	Kamaishi city	7.0%	-2,762 p.
Watari town	- 3.6%	-1,247 p.	Kawamata town[2]	- 7.0%	-1,090 p.
Shiogama city	- 4.1%	-2,295 p.	Hirono town	- 6.8%	-1,219 p.
Matsushima town	- 4.4%	-661 p.	Ofunato city	- 6.5%	-2,669 p.
Tamura city[2]	- 4.8%	-1,922 p.	Miyako city	- 4.8%	-2,861 p.

1) Local governmental areas evacuated due to radiation contamination and, designated as an alert zones and instructed evacuation zones that were difficult to return.
2) Local governmental areas including a restricted residential zones, a planned evacuation zones and zones of preparedness for cancel of instructed evacuation zones.
3) Other coastal areas in Fukushima prefecture.

they still must pay all of their living costs. The reconstruction of industrial facilities is the most important issue for the revitalization of the victimized population (**Fig. 1**).

Table 2 shows the population changes in these five years in the coastal areas based on the National Censuses from 2010–2015. In Iwate and Miyagi prefectures, the population of the Sendai metropolitan region including Natori City, Iwanuna City and Rifu Town increased by more than 42,000 people. The population in region of the other local governments decreased over the five years. The greatest population decrease was found in Onagawa Town. The population after the earthquake decreased by 37%, as more than 3,700 people left their hometowns or killed. The second was a 29% decrease in Minami-sanriku Town, as more than 5,000 people left town or were killed. The third was Yamamoto Town with a 26% decrease and a loss of 4,390 people. The fourth was Ozuchi Town with a 23% decrease and a loss of 3,540 people. The fifth was Rikuzen-takada City with a 15% decrease and a loss of more than 13,100 people.

In Onagawa Town, Minami-sanriku Town, Ozuchi Town and Rikuzen-takada City of the five most affected areas, every city hall and town hall was destroyed severely. Many officers were killed and missing and their homes were lost or damaged by the tsunami. Especially in Ozuchi Town, initially, the old town hall was damaged after violent shaking. Therefore, the mayor and other officers set up tents for an emergency headquarters in front of the town hall. approximately 30 minutes after the shaking began, a tsunami 15 meters high rushed toward the town hall and killed the mayor and many officers.

These disaster and damage situation were beyond the expectations of each local government's Disaster Management Plan established according to the Disaster Countermeasures Basic Law. They lost not only the town hall but all of documents, data, computers, and eventually, the officers and staff members. It was impossible to implement quick responses for emergency management in the face of such a huge tsunami. Before the tsunami formed, the only emergency announcement for evacuation was repeated on a broadcast communication system in each potentially affected area. Many people evacuated to various locations in the highlands. More than 15,000 people failed to escape the tsunami and were killed or were carried far beyond the town borders. Even today, more than 2,590 people are still missing. On the other hand, more than 3,400 people, 90% of whom were elderly, were killed during the evacuation period or while living in temporary shelters. These are considered "disaster-related deaths," which means that the emergency period, the evacuation period, and the temporary shelter period were very dangerous times for victims of the natural disaster.

In Fukushima prefecture, the East Japan earthquake caused more severe depression than in Iwate and Miyagi prefectures. The earthquake shook people and homes and the resulting tsunami rushed in 40 minutes to an hour later. The tsunami destroyed not only homes but the Fukushima Nuclear Power Station as well. The nuclear power station lost all electric control power and was destroyed by a hydrogen explosion. As a result, 11 local governmental areas were polluted by radiation and all residents had to evacuate multiple times to clean areas. The initial shaking caused homes to completely collapse and the tsunami rushed into the coastal areas and destroyed homes. Both shaking and the tsunami completely destroyed 15,190 homes and killed 1,650 people. After the disaster, many people had to repeatedly evacuate from polluted zones to the other areas. During these multiple, difficult evacuations, many people, especially the elderly, were killed. The number of related deaths reached 1,979 by December 2015 (Reconstruction Agency 2015).

In the five years after earthquake, more than 15,000 people were evacuated to other areas in Fukushima prefecture and more than 43,000 people were evacuated to areas outside of Fukushima prefecture. Each region in Fukushima is wrestling with the struggles of revitalization. However, nearly all residents from radiation-polluted areas have been evacuated to the other areas and many people continue to live outside their hometowns. This is especially true in areas designated as evacuation instructed zones, where all residents were forced to leave. **Table 2** shows that nobody has live in the four areas designated as an evacuation instructed zone and the population ratios of the other seven areas, which were partially designated as evacuation zones, excluding Kawamata Town and Tamura City, which had very few areas designated as evacuation zones. As a result of the pollution cleanup progress, the evacuation zones are being changed to alert zones, difficult to return zones, restricted residential zones, planned evacuation zones, and prepared zone of cancel an evacuation instructed zone (see notes to **Table 2**).

In the coastal areas, we see severe population decreases and the rapid aging of the community. Thus, it is a very important issue whether or not the younger generation who are from coastal areas and who moved to metropolitan regions and inland urban areas will be able to return to the coastal areas in near future. If they do not return to their hometowns, many coastal areas will be exhausted. It

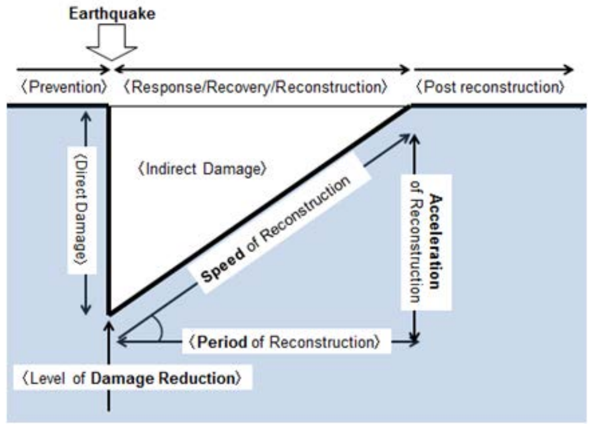


Fig. 2. Model of the disaster process: damage, response, recovery, and reconstruction.

will indeed be a local crisis for the autonomy of coastal areas if it remains difficult for residents to return to their hometowns now and in the near future. However, rehabilitation and revitalization of the Futaba region, which consists of 11 polluted areas and from which more than 52,000 people were evacuated, shall certainly be realized, albeit gradually.

3. A Compound Disaster as a "National Crisis"

3.1. Concept of a Compound Disaster

Figure 2 shows a model for disaster response and recovery. Some disasters cause direct damage when they occur and prompt responses against direct damage can reduce the expansion of such damage. A speedy recovery and steady reconstruction can reduce indirect damage. It is important for a speedy recovery and steady reconstruction to be glowing the capability of officials and the functions of the local government. If the damage from a disaster exceeds governmental capabilities, such area stands on the edge of a precipice for citizens.

It has been said that the 21st century will be a century of mega disasters and compound disasters, which will result in national crises. The East Japan earthquake was a compound disaster consisting of two other compound disasters. The first was the compound disaster of the earthquake and the tsunami in Iwate and Miyagi prefectures and the other was the compound of the earthquake, the tsunami, and radiation pollution in Fukushima prefecture. The result was double the damage of two individual disasters. The first disaster can cause slight damage as a result of shaking. However, when a second disaster hits an already damaged area, the scale and degree of damage will be larger and more severe than the simple sum of two separate disasters. In the case of the East Japan earthquake, the second disaster was caused by a tsunami. However, in the Fukushima area, a third disaster was caused by radiation pollution, which resulted from the second disaster,

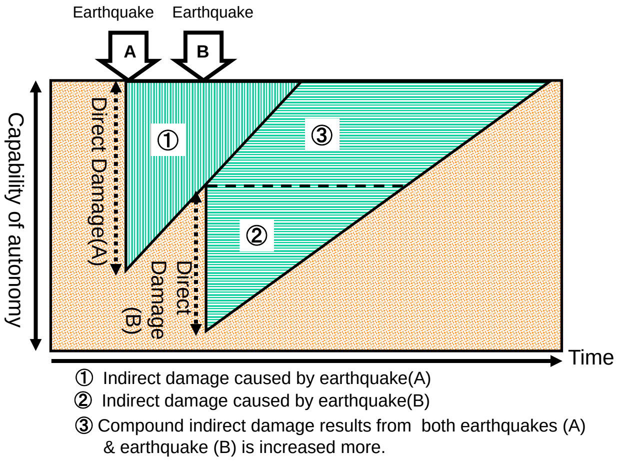


Fig. 3. Conceptual model for a "compound disaster with increased damage."

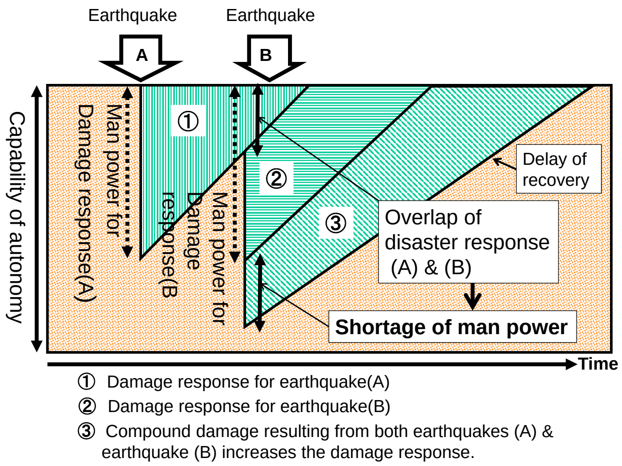


Fig. 4. Conceptual model for a "compound disaster with synchronous responses."

the tsunami. The third disaster was what caused nearly all of the related deaths of 1,979 people, which was more than the number of people killed by both the earthquake and the tsunami.

We can define two typical phenomena of compound disasters. The first type of compound disaster is defined as a "compound disaster with increased damages," such as the East Japan earthquake and the tsunami, which involved the same district experiencing repeated damage from various disasters. An image of this "compound disaster with increased damages" is shown in **Fig. 3**. Homes that may be slightly damaged by the first earthquake are destroyed by the second earthquake, even though the second is of the same force as the first because the anti-earthquake level of already damaged houses are lower than the level of a normal house.

The second type of compound disaster is defined as a "compound disaster with synchronous responses" and illustrated in **Fig. 4**. Disaster responses such relief, rescue, evacuation announcements, medical services, and so on are very important local government actions. These responses can reduce the volume of damage and decrease the number of victims, including related deaths. However, if two disasters occur simultaneously in different parts of one local government area, the number of official members and the amount of necessary materials and facilities for disaster response might be inadequate. In Japan, local governments were merged for rationalization of autonomy in the 2000s. After the merger of local governments, approximately 3,300 local governments were decreased to 1,700 local governments. This decrease resulted in an expansion of the governmental territory and a decrease in the number of officials for rationalization, which resulted in an increase in the number of residents per official. The expansion of governmental areas gave rise to the possibility of suffering from various disasters simultaneously and the decrease in the number of officials caused a shortage of manpower for disaster response.

3.2. Imminent Mega Disasters and Mega Damage Caused by Compound Disasters

As a result of the lessons learned from the East Japan earthquake, the Central Disaster Management Council (CMDC) has been conducting new damage estimation research of the two mega earthquake disasters, the Nankai trough earthquake and the Tokyo inland earthquake. Because the provability of the Kanto great earthquake, which is as same as the great Kanto earthquake of 1923, is low, damage estimations for this earthquake were made only as a basis for long-term measures.

(1) A magnitude 9.0 Nankai Trough earthquake

The CDMC has announced the provability of Nankai Trough earthquake of magnitude 9.0 is approximately 70% in next three decades. In 2012 and 2013, the CDMC conducted new damage estimation research on an M9 class Nankai Trough earthquake based on the lessons learned from the East Japan earthquake and published the results. Because the seismic zone of the Nankai Trough is located under the Pacific coastal areas of West Japan, the broad coastal districts are shaking strongly as level 7 and level upper 6 of the Japanese Seismic Intensity Degree (JSID). In coastal areas as well as the metropolitan areas of Osaka and Nagoya, where wooden houses are densely packed, houses can collapse on a massive scale. Shortly after the collapse of houses, a huge tsunami can strike these affected coastal areas and serious fires can burn the wooden houses in these crowded districts.

In the most severe case of the Nankai Trough earthquake disaster, the earthquake occurred on a winter evening, with winds reaching speeds of 8 m/s. The epicenter was located near and under the islands of Japan. The M9 earthquake resulted in the collapse of 1,480,000 homes, of which, 750,000 wooden homes were destroyed by fire and the tsunami completely destroyed 146,000 homes. Approximately 323,000 people were killed – including 230,000 people as a result of the tsunami – and 623,000 people were injured (**Table 3**). **Fig. 5** shows the distribution of building damage including homes that were collapsed as a result of shaking, destroyed by the tsunami, and destroyed by fire (**Figs. 5** and **6**).

Table 3. Comparison of previous great disasters and future massive disasters.

Items of damage		Nankai trough massive earthquake (CDMC 2013[1])	Tokyo inland Earthquake (CDMC 2013[2])	East Japan great earthquake[3] (11th March. 2011)	Hanshin-Awaji great earthquake[3] (17th January, 1995)
Hypocenter		Nankai trough	Inland earthquake	Nihon trench	Inland earthquake
Magnitude of quake		9.0	7.3	9.0	7.3
Wind speed & time		8m/s (evening)	8m/s (evening)	Calm (afternoon)	3m/s(early morning)
Major hazard		Strong shaking	After shock fires	Tsunami	Strong shaking
Human loss (persons)	Death[5]	323,000	23,000	18,600	5,500
	(Tsunami)	(230,000)	0	(18,370)	0
	Related[6]	-	-	3,410	930
	Injured	623,000	123,000	6,220	43,800
Building Damage (houses)	Collapse	1,480,000	198,000	6,800	104,900
	Burnt	750,000	412,000	(330 fires broke.)	7,000
	Tsunami	146,000	0	115,000	0
	Total	2,376,000	610,000	121,800	111,900
	Medium	-	-	278,500	144,300
Refugee (persons)		-	2.7 million	470,000	320,000
Cost of rebuilding[7]		169,500 billion yen	47,500 billion yen	26.0 billion yen	16,000 billion yen

1) Data is from the damage estimations of the CDMC, Nankai Trough earthquake WG (2013a, b, c, d)
2) Data is from the damage estimations of the CDMC, Tokyo inland earthquake WG (2013a, b, c, d)
3) Data is from the damage report on the East Japan great earthquake from the Fire and Disaster Management Agency, the Ministry of Internal Affairs and Communications, No. 153, published on March 8, 2016. The number of homes destroyed by shaking and number of homes destroyed by the tsunami are estimated by the author based on the damage statistics for each local area.
4) Data is from the damage report on the Hanshin-Awaji great earthquake from the Fire and Disaster Management Agency, the Ministry of Internal Affairs and Communications, final version published in May 2006.
5) Deaths includes those killed directly by home collapse, fire, tsunami, etc.
6) Related deaths mean those caused indirectly by worsening conditions during evacuations, in shelters, and as a result of other recovery processes. Ninety percent of related deaths involve the elderly. The concept of related deaths was authorized after the Hanshin-Awaji great earthquake.

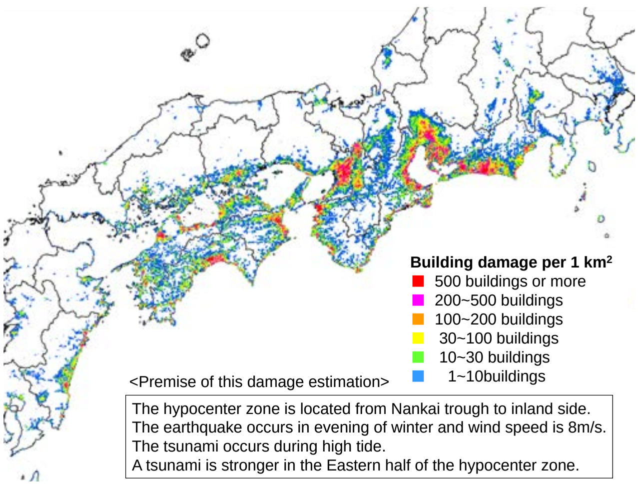


Fig. 5. Distribution of building damage during a Nankai Trough earthquake (CDMC 2012).

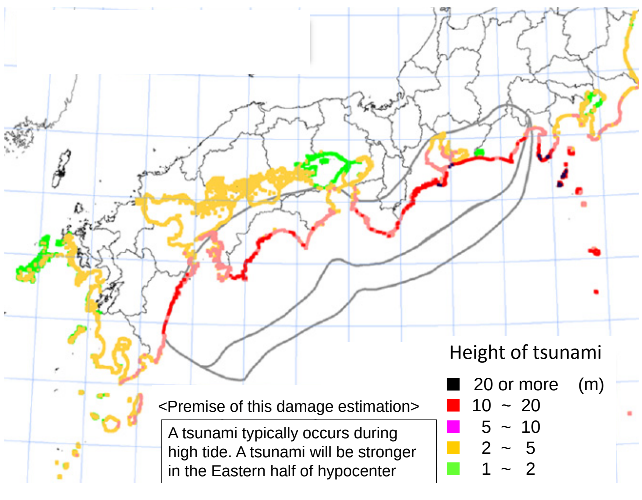


Fig. 6. Height of tsunami during a Nankai Trough earthquake (CDMC 2012).

According to damage estimation research (CDMC 2013a), the implementation of anti-earthquake measures can reduce home damage. If anti-earthquake measures are implemented such as retro-fitting old houses built before 1981, promoting automatic electric breakers, vitalizing community defense activities including tsunami evacuation exercises, and so on, the loss of 2,380,000 homes can be reduced to 800,000 and the deaths of 323,000 people can be reduced to 105,000. The CDMC enacted a new act on special measures for the promotion of Nankai Trough earthquake disaster management in 2014. According to the act, the CDMC designated 707 municipalities in 27 prefectures as Promotion Areas for Urgent Measures Against a Nankai Trough Earthquake and 139 municipalities in 14 prefectures were designated as Special Promotion Areas for Urgent Measures Against Tsunamis.

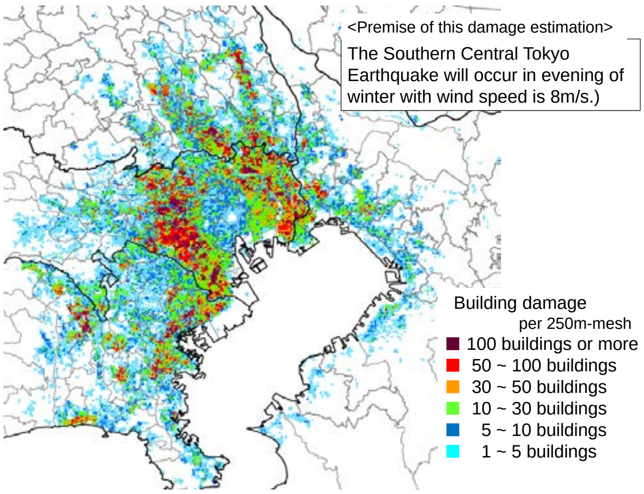


Fig. 7. Distribution of building damage during a Southern Central Tokyo earthquake (CDMC 2013a).

However, the destruction of 800,000 homes and the deaths of 105,000 people represent the most significant damage in Japanese history. How can we further reduce this damage?

(2) A magnitude 7.3 Tokyo inland earthquake

The CDMC has also estimated that there is a 70% chance of another Tokyo inland earthquake with a magnitude of 7.3 in next three decades. This estimation has not decreased since the East Japan earthquake but has actually increased and includes an aftershock similar to that of the M9.0 East Japan earthquake. The CDMC conducted new damage estimation research for a Tokyo inland earthquake of M7.3. The results of the research were published in 2013. However, the most important characteristic is that it is unknown where the Tokyo inland earthquake will occur. Depending on the land use of the area where the earthquake occurs, the quantity and quality of damage will be different. Therefore, 19 earthquake epicenters were established for different locations in the Tokyo metropolitan region. If the epicenter of an M7.3 earthquake is located approximately 10 kilometers under each city center in the Tokyo metropolitan region, then the assumed seismic intensity of every location in the epicenter will experience severe shaking at a JSID level 6 and a JSID level 7 in the lowland areas of the alluvial plain. This means that every municipality in the Tokyo metropolitan region must prepare and implement measures against severe shaking from a Tokyo inland earthquake. Therefore, the CDMC enacted the Act on Special Measures for Tokyo Inland Earthquakes in November 2013 and designated 309 municipalities from 10 prefectures as Urgent Promotion Areas from Emergency and Anti-earthquake Measures. However, this was enacted on the damage assumptions of a Southern Tokyo inland earthquake (a *toshin-nanbu* earthquake in Japanese), which is the largest type of earthquake and causes the most serious impacts on capital functions (**Fig. 7**).

Because the construction movement in the Tokyo metropolitan region has been very active of late, many old homes and buildings built before the 1981 seismic standards were implemented have been demolished and rebuilt using new, stronger construction. As a result, the damage to homes and buildings caused by a similar Tokyo inland earthquake has been reduced from approximately 850,000 homes to 610,000 (**Fig. 7**).

However, the volume of damage is five times the damage of the Hanshin-Awaji earthquake and of the East Japan earthquake (**Table 3**). There is also the potential of a mega disaster that we have not yet experienced. In addition, it is important to note that this type of damage will affect national business functions related to economic, political, administrative, and international activities.

4. The "Event Scenario Simulation Approach" to Mega Compound Disasters

It has been said that Japan is the empire of disaster. Geographically, Japan and the surrounding areas have 7 percent of the world's volcanic mountains and 20 percent of the world's earthquakes with a magnitude of more than 6.0. Additionally, an average of 10 typhoons strike the Japanese islands every year. The most severe disaster was the Kanto earthquake of 1923, which killed more than 100,000 people. In the case of volcanos, the 1792 explosion of Mt. Shimabara-Fugendake killed more than 15,000 people. In the case of typhoons, the Ise-wan typhoon of 1959 killed approximately 5,100 people as a result of a six-meter tidal wave.

In 21st century Japan, the activities of volcanos, earthquakes, and typhoons are very brisk. This means the potential for compound natural disasters is rising. If a severe typhoon strikes the disaster area of a volcanic explosion, mud flows on a mega scale could occur in the foothills and on every mountainside. If the ash that falls on the roofs of buildings gets wet by heavy rainfall, the weight of mud on roofs could cause the buildings to collapse, especially on wooden buildings.

If a mega typhoon strikes a metropolitan area where various damage has already occurred, the total damages could significantly increase. Many houses damaged by shaking collapse from strong winds and houses on hillsides may crack as a result of shaking and can be destroyed by heavy rainfall. If the shaking or liquefaction destroys river banks and seawalls, even light rainfall may cause severe flooding due to the inadequate capabilities of damaged river banks and seawalls. In the case of rainfall that does not typically cause flooding, if river banks and seawalls are damaged by an earthquake, even a little rainfall can cause severe flooding in lowland areas. The various urban functions of metropolitan areas are supported not only by lifeline systems such as electricity, communication, water, gas and sewage but also traffic systems such as subways, railways, highways, and tunnels. These services are discontinued for long periods of time after both earthquakes and flooding.

The tree major Japanese metropolitan areas are Tokyo, Osaka, and Nagoya, which are all located in lowland ar-

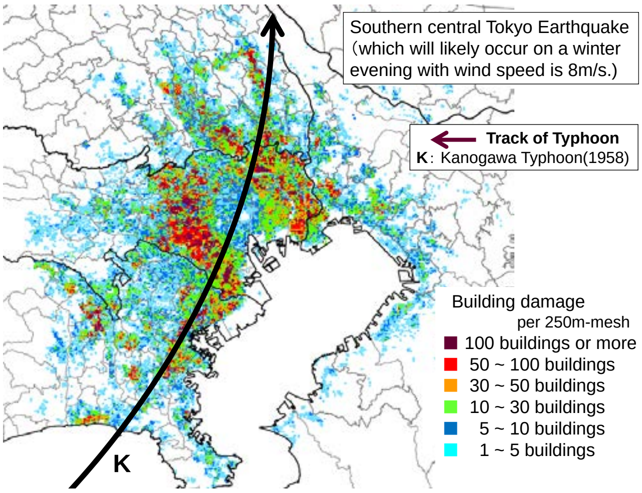


Fig. 8. Image of a compound disaster from a Tokyo inland earthquake and related typhoons.

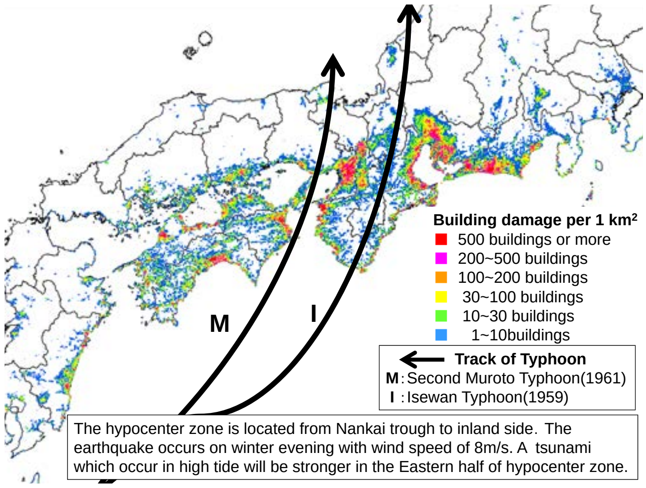


Fig. 9. Image of a compound disaster from a Nankai Trough earthquake and related typhoons.

eas near the estuaries of wide rivers. Large-scale and complex underground spaces have been developed in central areas, including subway stations and passages that connect various facilities through the basements of buildings. Flooding from typhoons that occur immediately after earthquakes, as with tsunamis, stop urban functions altogether. In Tokyo, urban functions include not only the central business functions of private companies but the central business functions of the national government.

Figure 8 is an image of a compound disaster in the Tokyo metropolitan area. On the damage map of the Tokyo inland earthquake that destroyed 610,000 homes, you can see that the track of the Kanogawa typhoon that struck Tokyo killing 1,269 people in 1958 overlapped. The Eastern part of Tokyo was flooded not only by a muddy river that damaged the river banks but also by tidal waves that crashed over the broken seawalls at the bottom of the Tokyo bay.

Figure 9 is an image of compound disaster from the Nankai Trough earthquake and associated typhoons. Osaka and Nagoya were destroyed both by seismic motion and fires after the earthquake. If the tsunami strikes Osaka Bay and then Ise-wan Bay, it is not so high. One or two weeks later, two mega typhoons might strike Osaka and Nagoya. On the damage map of the earthquake, the track of the Ise-wan typhoon of 1959 that killed 5,098 people and the track of the second Muroto typhoon of 1961, which killed 202 people, overlapped.

Damage from compound disasters such as those discussed above is not estimated yet. However, these events are potential scenarios for which disaster measures can be implemented. An approach to compound mega disasters was established in the "Event Scenario Simulation Approach." During this century, we must prepare to manage situations with which we are unable imagine coping. What situation is the most serious situation? We cannot estimate the greatest seriousness but we can imagine serious situations. This author has entitled this particular methodology the Event Scenario Simulation Approach. It is different from the traditional concept of disaster management. The concept of disaster management is based on an estimation of damages with which municipal personnel and resources can cope. Traditionally, a scale of damage widely bigger than a scale which can be copped has been ignored. Therefore, if megascale damages caused by an actual disaster are bigger than the assumed scale of damage, then it is likely that we will not be able to properly address these damages. We persuaded ourselves of it is a situation beyond an assumption and thought that it is very few case.

However, there is a 99 percent chance that a magnitude 9.0 earthquake will occur in North-east Japan in the next three decades. This was the case with the East Japan earthquake. Many people, including municipal officers, national officers, and seismology experts said that the damage from this earthquake exceeded the basic assumptions.

However, it is thought that mega disasters will occur several times in Japan during the 21st century. Every municipality must respond and be able to cope with these mega disasters. Therefore, we must imagine and assume the most serious situations in order to draft disaster management plans using the Event Scenario Simulation Approach. We must consider various measures to cope with mega disasters not from earthquake as a cause of disaster but from situation as an event of disaster.

5. What Measures Are Japanese Municipalities Taking to Address Compound Disasters?

Compound disasters have occurred in Japan throughout history. In 2004, the No. 23 typhoon of 2004 struck Niigata prefecture on October 21, 2004 and heavy rainfall continued throughout the night. The mountains of the mid-Niigata region were very wet but landslides and flooding did not occur. On the evening of October 23, the mid-Niigata earthquake with a magnitude of 6.8 oc-

Table 4. Outline of the municipality survey on compound disaster measures.

Year	Number of issue	Number of answer	Answer ratio
2011	792	384	48.5%
2012	792	377	47.5%
2013	795	275	34.6%
2014	795	277	34.8%

*Objective autonomy excludes cities affected by the East Japan earthquake.

Table 5. Revision of disaster measures in 2013.

Revised disaster measure	Number of cities	Ratio of revision
Hazard map of tsunami	76	27.6%1)
Damage estimation of earthquake	70	25.6%
Risk map of earthquake	50	18.2%
Risk map n of tsunami	46	16.7%
Hazard map of landslide	33	12.0%
Assumption of compound disaster for countermeasures.	29	10.5%
Hazard map of flood	29	10.5%
Risk map of landslide	26	9.6%
Risk map of flood	24	8.7%
Damage estimation of typhoon and flood	9	3.3%
There are not important measures that revised.	71	25.8%

*The number of responses from 2013 is 275.

1) This percentage is the proportion of all responding municipalities, not the number of coastal municipalities.

curred. A JSID level 7 was recorded and many landslides occurred. Because many roads to the city citer were destroyed, several villages were alone. Many people evacuated from mountain villages to urban locations due to heavy snowfall and remained in temporary housing in the central city for two and half years.

On June 28, 1948, the Fukui earthquake, with a magnitude of 7.1, occurred on the Fukui plain. Over 30 percent of all wooden houses in many villages collapsed. The severe damage ratio was the result of a JSID level 7. In late July, very heavy rainfall of more than 450 mm over three days fell on the Fukui plain and in the neighboring mountains. Because the banks of the river were destroyed by the earthquake one month prior, muddy streams flowed over the damaged river banks. The earthquake disaster area expanded due to flooding and the damage augmented continuously.

During this century, as mentioned in Section 4, it is certain that several largescale compound disasters will occur in Japan. How will municipalities prepare for and take measures against such huge compound disasters? We conducted a questionnaire survey on compound disasters and anti-disaster measures based on the lessons learned from the East Japan earthquake (**Table 4**).

Objective autonomy is all of cities without affected by the East Japan earthquake.

Hazard means that "power" was the cause of the disaster. Risk is the product of the damage volume and the provability of the hazard. **Table 5** is a revision of the disaster information for preparedness against and survival of various hazards taken from the lessons learned after the East Japan earthquake of 2013.

Most of the cities revised the hazard map for a tsunami because the most severe damage from the East Japan earthquake was caused by the tsunami. Almost all cities located along the coast revised or produced a new hazard map for a tsunami and distributed it. Additionally, many municipalities revised the risk map with information for both earthquakes and tsunamis and distributed it.

The risk maps, which added anti-disaster information, are often produced through a collaboration with residents and municipality officials as part of a neighborhood or community anti-disaster exercise in Japan. This is an effective way to raise awareness of anti-disaster activities in a neighborhood or community. However, it is difficult to implement in every community. Therefore, each municipality revised or produced various risk maps and distributed them to every family.

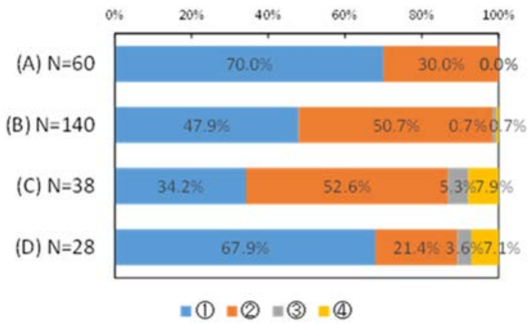
On the other hand, hazard maps and risk maps for landslides and floods were not significantly revised. After the East Japan earthquake, many municipalities implemented revision measures for tsunamis and earthquakes but not for other disasters.

In addition, 70 cities revised the damage estimation of earthquakes. Originally, this revision was implemented only by major cities because damage estimation research is costly. Nearly all of the smaller cities used the damage estimation research conducted by the prefecture. This damage estimation is an assumption for the revision of a disaster management plan as a basic plan for the municipality's activities.

Additionally, 71 municipalities answered that there are no important measures that need to be revised. However, the compound disaster assumptions for countermeasures were implemented by 29 municipalities. Based on this survey, we see that several cities have begun to consider

Table 6. Addition of measures to address compound disasters in a period 2011-2014.

	2011	2012	2103	2014
The measures against compound disaster are not provided yet.	76.4 %	68.0 %	63.0 %	54.2 %
The measures against compound disaster are added in the disaster management plan.	17.3 %	28.3 %	33.0 %	42.1 %
The others	6.0 %	3.7 %	4.1 %	3.7%
Total sum	100.0%	100.0%	100.0%	100.0%



(A) The measures against compound disaster are not provided yet.

(B) The measures against compound disaster are added in the disaster management plan.

(C) In addition to disaster management plan, the response manuals against compound disaster are provided.

(D) The others

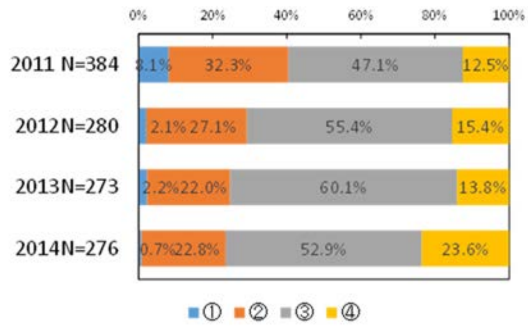
① The principal policy of disaster management issue is no clarified yet.

② The principal policy of disaster management issue is clarified in the master plans of various fields.

③ In addition to the above, the plan of comprehensive measures against disasters is established.

④ An ordinance for clarification of the principal policy of disaster management issue is established and a regulation for implementation of compound disaster measures.

Fig. 10. Relationship between measures to address compound disasters and the establishment of a principal policy for disaster management in 2014.



① The co-support agreements on disaster are not concluded with any municipality.

② The co-support agreements on disaster are concluded with the neighboring municipality in the same prefecture

③ In addition to the above, the co-support agreements are concluded with the distant municipality, which shall not be affected by same disaster at once.

④ According to co-support agreements, exchange and exercises of both officials are done usually.

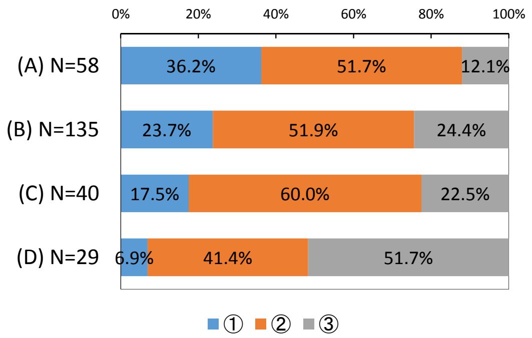
Fig. 11. Ratio of co-support agreements concluded in a period 2011-2014.

the compound disaster issue (**Table 5**).

The situation of drafting new measures for compound disasters has progressed during the period 2011-2014. In 2011, 76.4 percent of municipalities had not yet provided measures for compound disasters. This percentage decreased year by year to 54.2 percent in 2014. In contrast, 17.3 percent of municipalities added compound disaster measures to their disaster management plans. This percentage continued to increase year by year to 42.1 percent in 2014. Many municipalities have learned from the East Japan earthquake that it is important to take measures against potential compound disasters (**Table 6**).

This author assumes that municipality capabilities will grow year by year if a principal policy for continuous implementation of anti-disaster measures is established. **Fig. 10** clarifies this assumption. Municipalities that established a principal policy for disaster management in various master plans added measures for compound disasters and provided response manuals for compound disasters as well. However, there are very few municipalities that established a plan for comprehensive disaster measures or enacted an ordinance or regulation announcing the establishment of a principal policy for disaster management and measures to address compound disasters (**Fig. 10**).

In addition, the municipalities that are prepared for compound disasters, which will continue to grow on a mega scale, are more inclined to conclude co-support agreements for disaster response not only with neighboring municipalities but also with distant municipalities that may suffer from the same events. Co-support agreements are very important to ensure effective co-support in a time of disaster that is co-exercised by officials and members of the public from both municipalities. According to **Fig. 11**, these trends have been increasing year by year and according to **Fig. 12**, municipalities who establish a principal policy for a disaster management are more likely to conclude co-support agreements as well.



(A) The principal policy of disaster management issue is no clarified yet.

(B) The principal policy of disaster management issue is clarified in the master plans of various fields.

(C) In addition to the above, the comprehensive plan of measures against disasters is provided.

(D) The principal policy of disaster management issue is provided as an ordinance or a regulation.

① The co-support agreements on disaster are concluded with the neighboring autonomies in the same prefecture.

② In addition to the above, the co-support agreements are concluded with the distant autonomies, which shall not be affected by same disaster at once..

③ According to co-support agreements, exchange and exercises of both officials are done usually.

Fig. 12. Relationship between the principal policy for disaster management and the conclusion of co-support agreements.

6. National Resilience Efforts to Thwart a National Crisis

At some point in the 21st century, a mega disaster on a scale that we have not yet experienced shall occur. As mentioned in Sections 4 and 5, a Nankai Trough earthquake would destroy 2,400,000 buildings and cause the deaths of 320,000 people and a Tokyo Inland earthquake would destroy 610,000 buildings and cause the deaths of 23,000 people.

Currently, Japan is an important member of the global economy in spite of a significant national debt 10 times the annual national budget and the fact that Japanese society is rapidly progressing to a super-aged society. In addition to these situations, recovery and reconstruction from the East Japan earthquake is continuing. In the five years after the earthquake, recovery and an almost complete reconstruction of infrastructure can be seen in Iwate and Miyagi prefectures. That being said, the rebuilding of homes and job development for returning victims who left their damaged hometowns are not yet complete. In addition, the recovery of Fukushima, especially the Futaba region, which was polluted by radiation after the nuclear power station accident, will need much more time to fully recover.

If a Nankai Trough earthquake or a Tokyo inland earthquake occurs before the completion of reconstruction

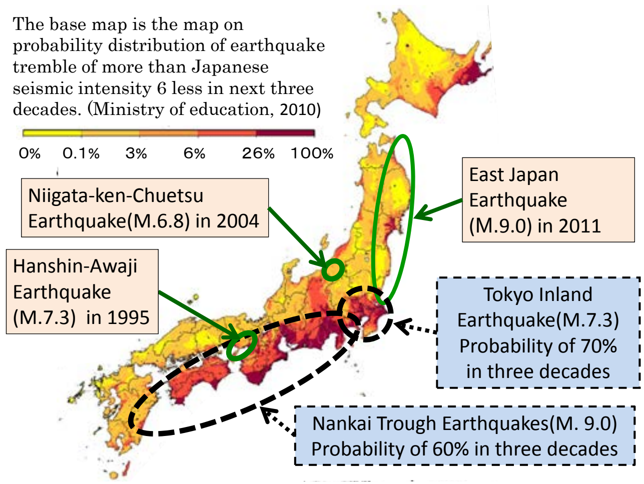


Fig. 13. Japan's earthquake disaster management needs.

from the East Japan earthquake, damages on a mega scale as described above shall cause a national crisis in Japan. In order to evade a national crisis caused by a mega disaster, it is necessary to quickly and steadily address not only the creative reconstruction of East Japan, whose regional vitality continues to grow, but also revolutionary disaster prevention measures against both a Nankai Trough and a Tokyo inland earthquake (**Fig. 13**).

In 2013, the CDMC published damage estimations for these two mega earthquake disasters and the Cabinet Office enacted the Act on Special Measures for a Nankai Trough Earthquake and the Act on Special Measures for a Tokyo Inland Earthquake. In the same year, the Cabinet Office enacted the Basic Law on National Resilience *(Kokudo kyoujinka kihonho)* for building a resilient nation to defend against large-scale disasters. The National Resilience Plan *(Kokudo kyoujinka kihon keikaku)* was established and announced in 2014. Today, all prefectures have established or are in the process of establishing a Prefectural Plan for National Resilience and a few municipalities have established or are establishing a Local Plan for National Resilience.

The present author is a member of the National Resilience Working Group in the Cabinet Office. Based on the advice of several prefectures and municipalities in drafting a plan for national resilience, the municipality's efforts to ensure national resilience based on a local plan is the most important issue for the prevention of damage to homes, for addressing mega disasters including compound disasters by reducing damages, for saving the lives of citizens, and for business continuity and continued economic activities in the global economy.

The present author considers that two goal levels are necessary for the completion of national resilience. The first goal level is a short-term goal to achieve as quickly as possible for cope with any mega disaster through the Business Continuity Plan (BCP) approach. In the East Japan earthquake, a mega tsunami destroyed local functions including administrative functions, medical services, industrial functions, lifelines, commercial services, and so on.

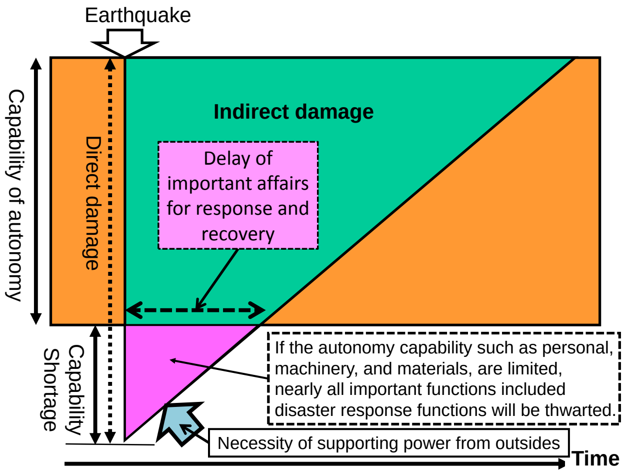


Fig. 14. Illustration of catastrophic damage caused by a mega disaster.

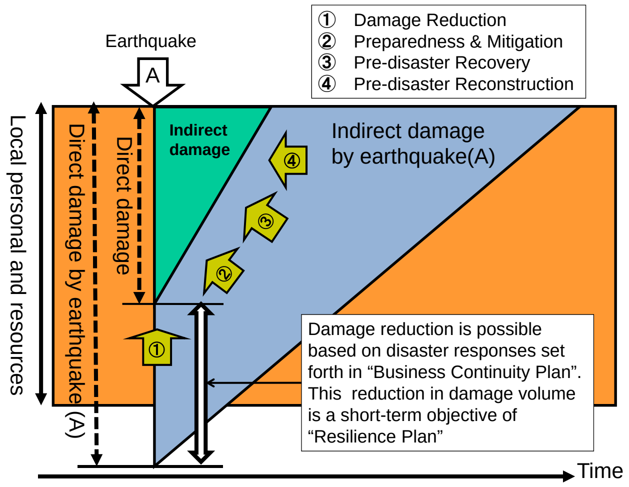


Fig. 15. Damage reduction as a short-term goal of national resilience.

This situation is illustrated in **Fig. 14**. Some municipalities lost all of their materials and facilities and several officials perished along with the city hall. All of the buildings and lifelines were destroyed. This volume of loss is more than a municipality can handle. As a result, nothing was accomplished for several days following the tsunami. Thus, important services were delayed such as the ability to rescue, relieve, and treat the injured; to distribute emergency food and water; and to set up evacuation shelters and care for the disabled. As a result, the number of both direct and related deaths increased.

If the scale of damage is reduced even slightly and if the scale of damage is at the level of disaster response within the capabilities of the BCP, municipality and industrial organizations might be able to respond to and mitigate damages from a mega disaster. If the scale of damage caused by the earthquake and the tsunami is greater than the assumptions in the BCP, the short-term goal for national resilience is decided as a reduction of damage until a level of damage that would be able to response and cope with important matters precedently (**Fig. 15**).

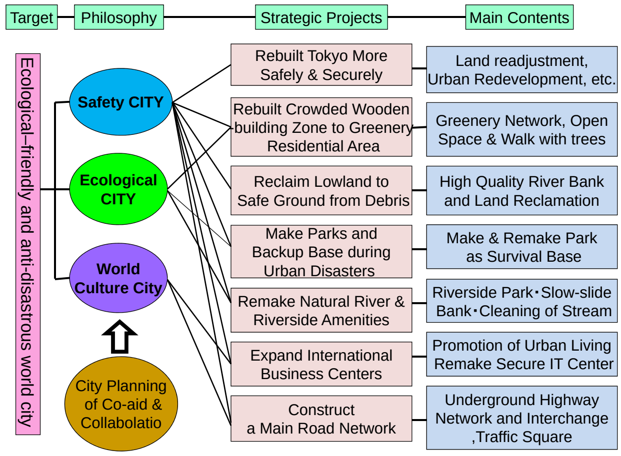


Fig. 16. Tokyo Pre-disaster Reconstruction Plan – Contents of the Tokyo Reconstruction Design (Nakabayashi 2012; Tokyo Metropolitan Government 2001).

The second-level goal is a long-term goal to improve and reconstruct a city/town/village after a mega disaster. Even if the most severe damage resulted from a mega disaster, the municipality should be able to recover and reconstruct the city and local communities. What kind of city and district should the municipality and local communities reconstruct during that time? They might reconstruct a comfortable, convenient, healthy, and secure city with necessary amenities. We can create a vision of urban reconstruction without loss and damages based not only on damage estimations for a huge disaster but also for the severe situation that can be imagined through an Event Scenario Simulation Approach. Additionally, we can prepare planning manuals for reconstruction plans and processing manuals for smooth negotiations and agreements for reconstruction after a mega disaster (Nakabayashi 2012; Nakabayashi et al. 2006).

The Tokyo Metropolitan Government (TMG) started "pre-disaster recovery and reconstruction plan" projects based on lessons learned from the Hanshin-Awaji earthquake of 1995. The TMG published a vision for the reconstruction of Tokyo after the Tokyo inland earthquake entitled "Design for Urban Reconstruction after an Earthquake" (TMG 2001). **Fig. 16** illustrates the content of the design. Seven strategic projects were prepared. Such a vision must be the long-term goal of urban planning and projects in the pre-disaster period. Urban reconstruction must not be implemented in a damages after a disaster but be before a disaster in the pre-disaster period. Efforts for pre-disaster recovery and reconstruction can be realized to create a more resilient city, resilient region, and resilient nation.

7. Concluding Remarks

In the 21st century, the scaling up of disasters will continue not only in Japan but throughout the world. We must prepare for mega disasters such as super typhoons with winds over 200 miles per hour, mega earthquakes with magnitudes of 9 accompanied by huge tsunamis, severe inland earthquakes that directly strike huge metropolitan areas, super heavy rainfall that could flood mega cities, and so on. Since the post-World War II period, disaster science and technology has progressed rapidly. Today, we can know a disaster is coming before it strikes. However, the number of disasters will continue to increase. The scale of disasters is expanding. It is thought that population growth itself has expanded the scale of disaster.

In order to overcome a mega disaster, we look toward new methodologies for the implementation of disaster prevention, mitigation, recovery, and reconstruction in the pre-disaster period. Highly technological information is not effective if we do not make efforts to reduce damage and encourage preparedness for safe evacuations in each community during the pre-disaster period. The conception of national resilience in Japan confirms the importance of "disaster prevention." What we need in the 21st century is not more scientific technology but more social technology to disseminate disaster-related information and to increase the knowledge of society regarding the implementation of disaster prevention measures in the pre-disaster period.

References:

[1] Central Disaster Management Council, Working group of measures of Nankai trough earthquake 2012, "Report on damage estimation of Nankai trough massive earthquake (First report)," Chuou bousai kaigi, Nankai torough kyodai jisin taisaku kento working group; Nankai trough kyodai jisin no higai-sotei ni tuite (Dai ichiji hokoku), 2012 (in Japanese), http://www.bousai.go.jp/jishin/nankai/taisaku/pdf/2_1.pdf

[2] Central Disaster Management Council, Working group of measures of Tokyo inland earthquake, "Report on damage estimation and measures of Tokyo inland earthquake (Final version) ∼ Document∼," Chuou bousai kaigi, Syuto-tyokka jisin taisaku kento working group; "Syuto chokka jisin no higai-sotei to taisaku ni tuite (Saisyu hokoku) ∼ Honbun∼," 2013a, (in Japanese), http://www.bousai.go.jp/jishin/syuto/taisaku_wg/pdf/syuto_wg_report.pdf

[3] Central Disaster Management Council, Working group of measures of Tokyo inland earthquake, "Report on damage estimation and measures of Tokyo inland earthquake(Final version), Annexure No.1 ∼ Human loss and construction damage (Quantity estimation) ∼," Chuou bousai kaigi, Syuto-tyokka jisin taisaku kento working group; "Syuto chokka jisin no higai-sotei to taisaku ni tuite (Saisyu hokoku), Betteb shiryo 1 ∼ Jinteki-butteki higai (Teiryo-teki na higai)∼," 2013b (in Japanese), http://www.bousai.go.jp/jishin/syuto/taisaku_wg/pdf/syuto_wg_siryo01.pdf

[4] Central Disaster Management Council, Working group of measures of Tokyo inland earthquake, "Report on damage estimation and measures of Tokyo inland earthquake(Final version), Annexure No.2 ∼ Aspect of damage on facilities ∼," Chuou bousai kaigi, Syuto-tyokka jisin taisaku kento working group; "Syuto chokka jisin no higai-sotei to taisaku ni tuite (Saisyu hokoku), Betteb shiryo 2 ∼ Shisetu nado no higai no yoso∼," 2013c, (in Japanese), http://www.bousai.go.jp/jishin/syuto/taisaku_wg/pdf/syuto_wg_siryo02.pdf

[5] Central Disaster Management Council, Working group of measures of Tokyo inland earthquake, "Report on damage estimation and measures of Tokyo inland earthquake (Final version), Annexure No.3 ∼ Aspect of economic loss∼," Chuou bousai kaigi, Syuto-tyokka jisin taisaku kento working group; "Syuto chokka jisin no higai-sotei to taisaku ni tuite (Saisyu hokoku), Betteb shiryo 3 ∼ Keizai-teki na higai no yoso∼," 2013d, (in Japanese), http://www.bousai.go.jp/jishin/syuto/taisaku_wg/pdf/syuto_wg_siryo03.pdf

[6] Central Disaster Management Council, Working group of measures of Nankai trough earthquake, "Report on damage estimation and measures of Nankai trough massive earthquake(Second report), ∼ Intention of damage estimation (second report)∼." Chuou bousai kaigi, Nankai torough kyodai jisin taisaku kento working group; "Nankai trough kyodai jisin no higai-sotei ni tuite (Dai niji hokoku) ∼ Higai sotei (Dai niji hokoku) no syushi nado ni tuite∼," 2013e, (in Japanese). http://www.bousai.go.jp/jishin/nankai/taisaku_wg/pdf/20130318_shiryo1.pdf

[7] Central Disaster Management Council, Working group of measures of Nankai trough earthquake, "Report on damage estimation and measures of Nankai trough massive earthquake(Second report), ∼ Damage of facilities and buildings (Aspect of damage)∼." Chuou bousai kaigi, Nankai torough kyodai jisin taisaku kento working group; "Nankai trough kyodai jisin no higai-sotei ni tuite (Dai niji hokoku) ∼ Shisetu nado no higai (Higai no yoso)∼," 2013f, (in Japanese). http://www.bousai.go.jp/jishin/nankai/taisaku_wg/pdf/20130318_shiryo2_1.pdf

[8] Central Disaster Management Council, Working group of measures of Nankai trough earthquake, "Report on damage estimation and measures of Nankai trough massive earthquake(Second report), ∼ Damage of facilities and buildings (Quantity estimation of damage)∼." Chuou bousai kaigi, Nankai torough kyodai jisin taisaku kento working group; "Nankai trough kyodai jisin no higai-sotei ni tuite (Dai niji hokoku) ∼ Shisetu nado no higai (teiryo-teki na higai-ryo)∼," 2013g (in Japanese). http://www.bousai.go.jp/jishin/nankai/taisaku_wg/pdf/20130318_shiryo2_2.pdf

[9] Central Disaster Management Council, Working group of measures of Nankai trough earthquake, "Report on damage estimation and measures of Nankai trough massive earthquake(Second report), ∼ Economic damage∼." Chuou bousai kaigi, Nankai torough kyodai jisin taisaku kento working group; "Nankai trough kyodai jisin no higai-sotei ni tuite (Dai niji hokoku) ∼ Keizai-teki na higai∼," 2013h (in Japanese). http://www.bousai.go.jp/jishin/nankai/taisaku_wg/pdf/20130318_shiryo3.pdf

[10] Fire and Disaster Management Agency, Ministry of internal affairs and communications 2016 "Damage report on the pacific ocean offshore and north-east Japan earthquake ∼ East Japan great earthquake∼," No,153, published in 8th March 2016. Somusyo Syobotyo "2011 tohoku chiho Taiheiyo oki jishin ∼ Higashi nihon daishinsai∼ ni tuite," 2016, Dai 153 ho,(in Japanese) http://www.fdma.go.jp/bn/higaihou_new.html

[11] Fire and Disaster Management Aagency, Ministry of internal affairs and communications 2016 "Damage report on the Hanshin-Awaji earthquake (Final version in 19th May 2006)." Somusyo Syobotyo Hanshin-Awaji daishinsai ni tuite, (Kakutei ho), 2016, (in Japanese), http://www.fdma.go.jp/data/010604191452374961.pdf

[12] Institute of Social Engineering(1972) "Long-term and timeline analysis on distribution of population in Japan islands." Syakai-kougaku kenkyujo "Nihon-reto niokeru jinko-bunnpu no tyoukiteki-jikeiretsu bunseki," 1972, (in Japanese).

[13] I. Nakabayashi, S. Aiba and T. Ichiko"Pre-disaster reconstruction measures of preparedness for post-disaster restoration in Tokyo," J. of Disaster Research, Vol.3, No.6, pp. 407-421, 2008.

[14] I. Nakabayashi "How to optimize the urban recovery after earthquake disaster – preparedness for recovery from the next Tokyo earthquake –," J. of Disaster Research, Vol.7, No.2, pp. 227-238, 2012.

[15] I. Nakabayashi, "East Japan Mega Earthquake and Dual Reconstruction schem – Regional and National Planning of Post-disaster and pre-disaster Recovery –," K. Okamoto and Y. Ishikawa (Eds.), "Traditional Wisdom and Modern Knowledge for the Earth's Future – Lectures Given at the Plenary sessions of the International Geographical Union Kyoto Regional Conference, 2013 –," pp. 135-163, Springer, Japan, 2014.

[16] National astronomical observatory "Chronological Scientific Tables 2015," p. 1108, Maruzen, Japan, 2015, Kokuritu-tenmondai "Rika Nenpyo" No.85, Maruzen, 2015 (in Japanese).

[17] Reconstruction Agency, "Number of Related Deaths in the East Japan earthquake – Result of research on 20th September 2015 –," Hukko-cyo (2015) "Higashi-nihon daisinsai ni okeru shinsai-kanrenshi no sisyasu – Heisei 27 nen 9 gatsu 30 nichi genzai tyosa kekka –," 2015, http://www.reconstruction.go.jp/topics/main-cat2/sub-cat2-6/ 20151225_kanrenshi.pdf

[18] Tokyo Metropolitan Government, "Ground Design of Urban Reconstruction from rathquke," 2001, (revised 2016), Tokyo to "shinsai hukkou girando dezainn" http://www.toshiseibi.metro.tokyo.jp/bosai/gd/

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Selected Publications:
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- I. Nakabayashi, "How to Optimize the Urban Recovery after Earthquake –Preparedness for Recovery from the Next Tokyo Earthquake–," J. of Disaster Research, Vol.7, No.2, 99. pp. 227-238, 2012.
- I. Nakabayashi, "East Japan Mega Earthquake and Dual Reconstruction Scheme – Regional and National Planning of Post-disaster and Pre-disaster recovery," TRADITIONAL WISDOM AND MODERN KNOWLEDGE FOR THE EARTH's FUTURE, Springer, Germany, pp. 135-163, 2014.3.

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