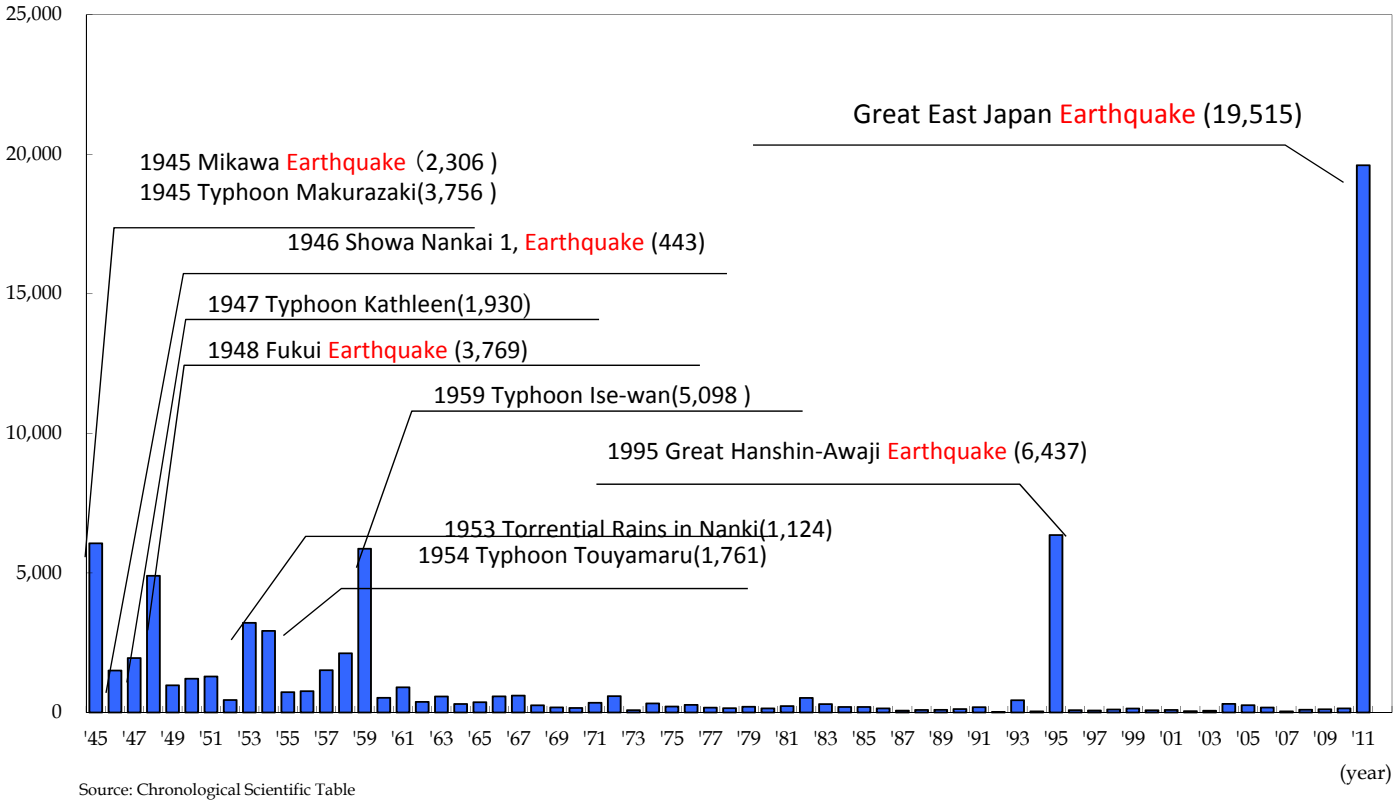
The Damage Estimation on the Nankai Trough Megathrust Earthquake

Disaster Management Bureau

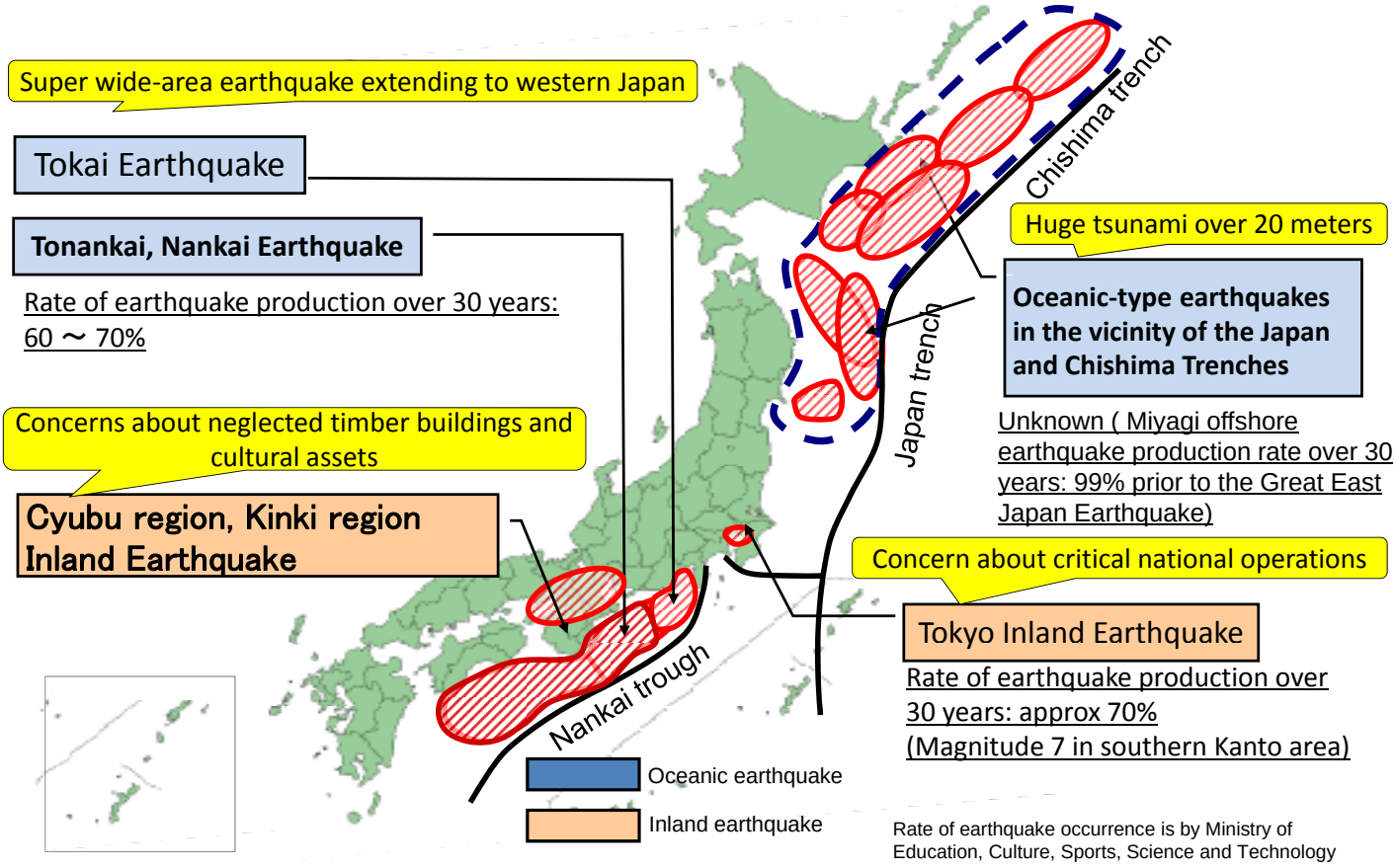
Cabinet Office, Government of Japan

Number of Deaths and Missing Persons in Previous Disasters



Source: Chronological Scientific Table

Large Earthquakes Reviewed by the Central Disaster Management Council



Planning and Review for Countermeasures Against Earthquakes

(1) Estimate distribution of seismic intensity, tsunami height, etc.

⇩

(2)Estimate likely damage

⇩ Deaths, buildings, fire, transportation, transit facilities, supply of utilities, waste disposal facilities, communications systems, etc.

(3) Countermeasures

Master planning from prevention through to emergency response, recovery and rebuilding

⇨ (4) Earthquake disaster management strategy

Set quantitative targets for disaster prevention, implementation plans, etc.

⇨ (5) Emergency response activity overview ⇨ (6) Firm action plan

Decide on the activities to be carried out by each organization and the level of support required in case of earthquakes

Countermeasure Overview for Tonankai & Nankai Earthquakes(Dec.2003)

Preparedness

・Build earthquake resistant housing and public buildings
・Upgrade and make the transportation network(land-sea-air)earthquake resistant
・ Drive long-term earthquake impact countermeasures
・ Drive cultural asset protection countermeasures

Tsunami

- **Upgrade facilities**
  - ・Automate the operation of floodgates
  - ・Maintain and upgrade seawalls
- **Evacuation countermeasures**
  - ・Secure evacuation centers and evacuation routes
  - ・Information dissemination to citizens
  - ・Non-emergency use of tsunami evacuation buildings
  - ・Maintenance of hazard maps
  - ・Dissemination of disaster preparedness knowledge

Wide-area

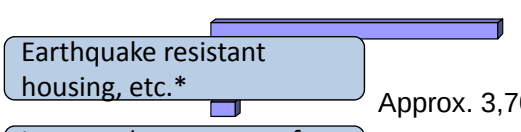
- **Improve community disaster management**
  - ・Enhance disaster education
  - ・Create an autonomous disaster organization
  - ・Maintenance of communication methods
  - ・Stockpile large volumes of essential goods
- **Establish an earthquake support plan**
  - ・Sharing of information
  - ・Maintenance of an activity base to support the public
  - ・Support for isolated communities (using helicopters, etc.)
  - ・Maintenance of disaster management centers
  - ・Implementation of an emergency response activity plan

Earthquake Disaster Management Strategy for Tonankai & Nankai Earthquake (Mar.2005)

Disaster prevention target:
Deaths and economic impact to be Reduced by Half within 10 years

Deaths

Approx. 17,800 persons → Approx. 9,100 persons (8,700 persons)
(deaths due to the tsunami ~8,700 persons)



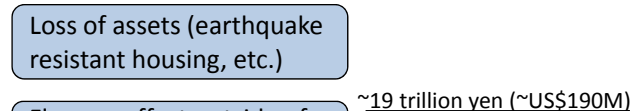
- Earthquake resistant housing, etc.* — Approx. 3,700 persons
- Improved awareness of tsunami evacuation plans — Approx. 3,600 persons
- Maintenance of coastal facilities — Approx. 800 persons
- Reduced fires due to earthquake resistant housing — Approx. 300 persons
- Countermeasures for steeply-inclined areas prone to landslides — Approx. 300 persons

*Example of a specific target

Ratio of earthquake resistant housing 75% to 90%

Economic Impact

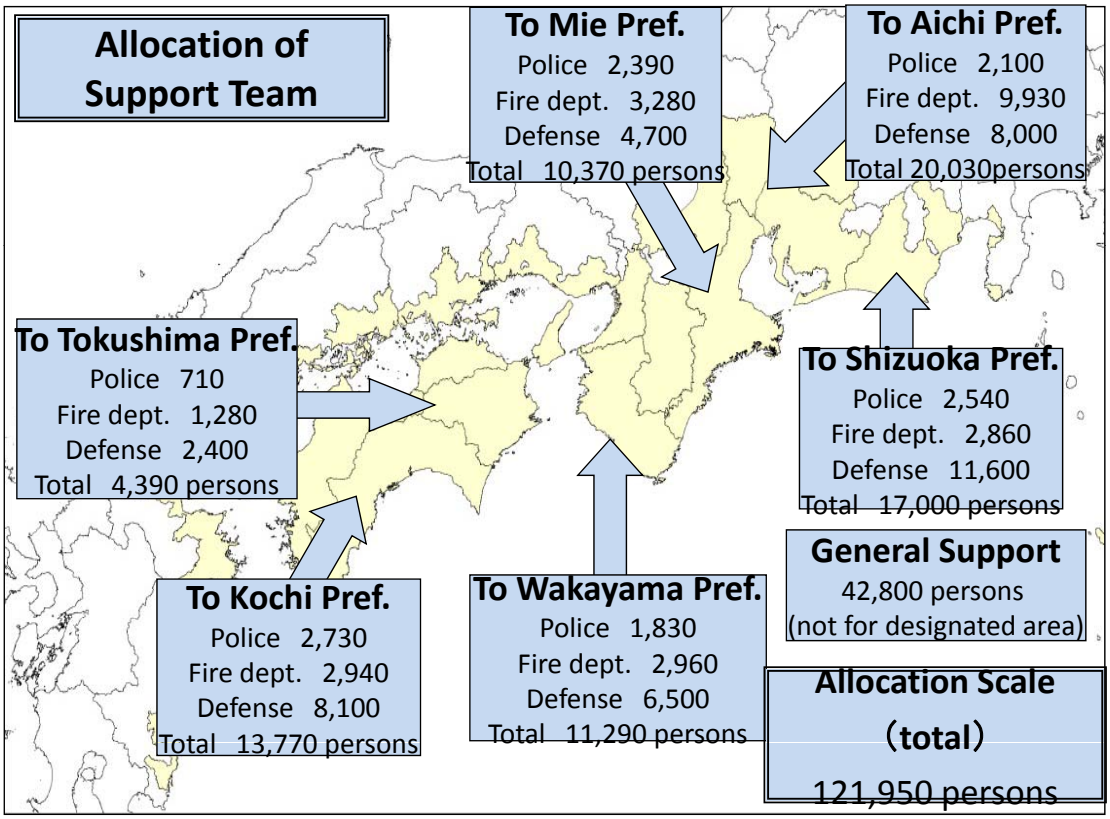
Approx. 57 trillion yen (~US$570M) → Approx. 31 trillion yen (~US$310M) (27 Trillion Yen (~US$270M))



- Loss of assets (earthquake resistant housing, etc.) — ~19 trillion yen (~US$190M)
- Flow on effect outside of the affected region — ~4 trillion yen (~US$40M)
- Interruption to production activities (secure labor and assets for business) — ~3 trillion yen (~US$30M)
- Restriction of east and west arterial traffic (earthquake resistant bridges, etc.) — ~1 trillion yen (~US$10M)

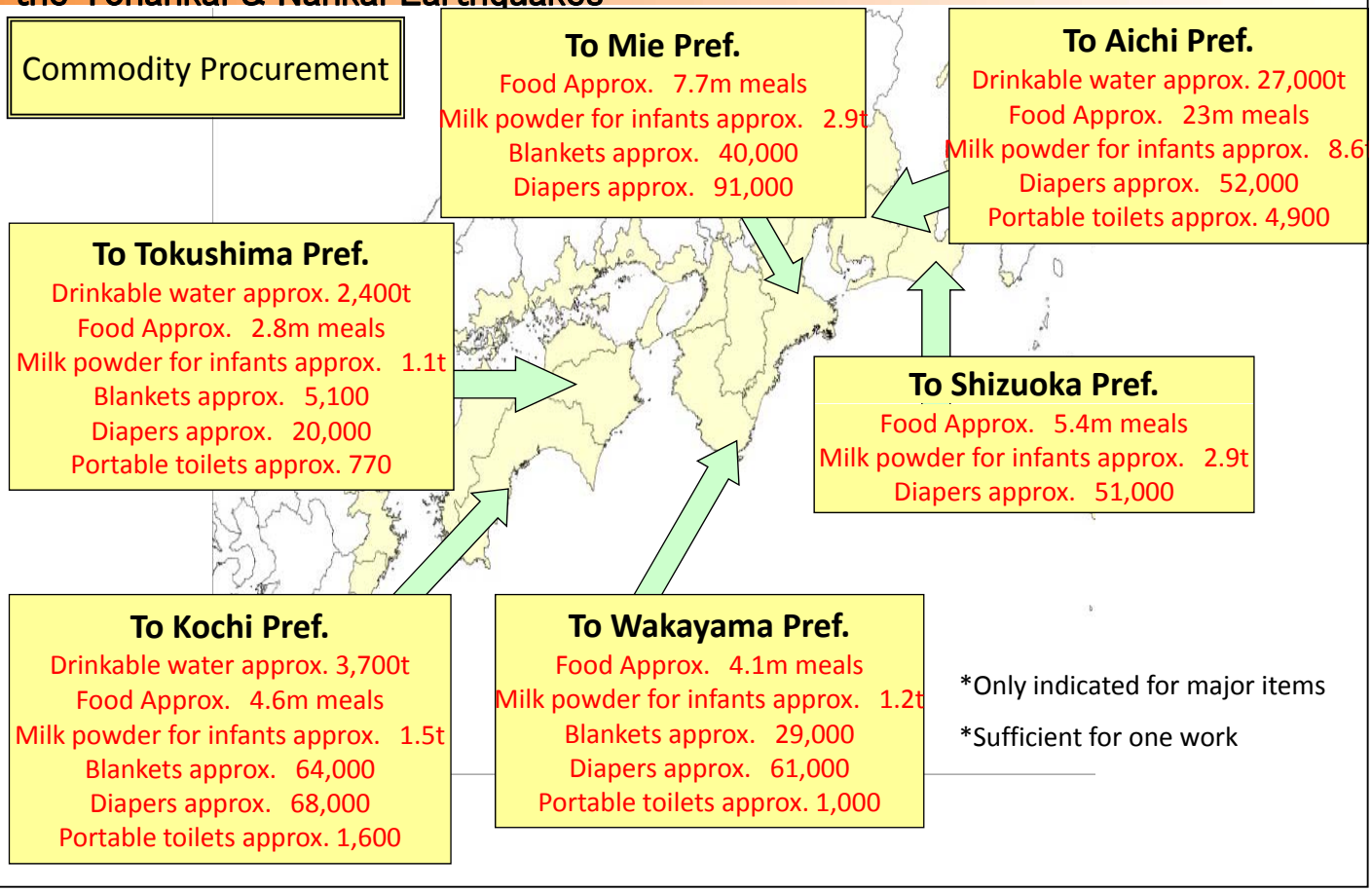
Activity Plan Based on Earthquake Disaster Management Countermeasures for the Tonankai & Nankai Earthquakes

(Mar.2005)



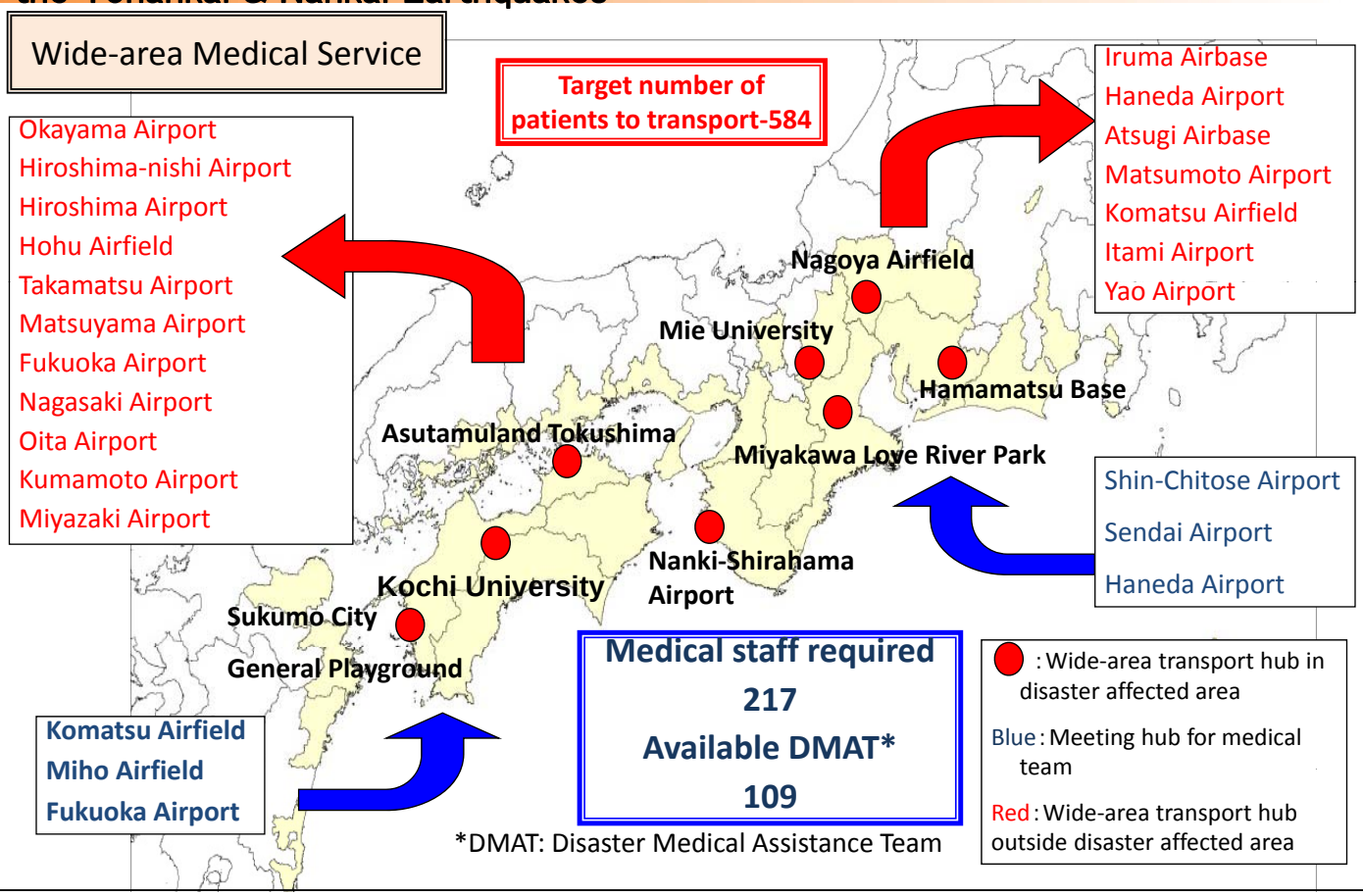
Activity Plan Based on Earthquake Disaster Management Countermeasures for the Tonankai & Nankai Earthquakes

(Mar.2007)



Activity Plan Based on Earthquake Disaster Management Countermeasures for the Tonankai & Nankai Earthquakes (Mar.2007)

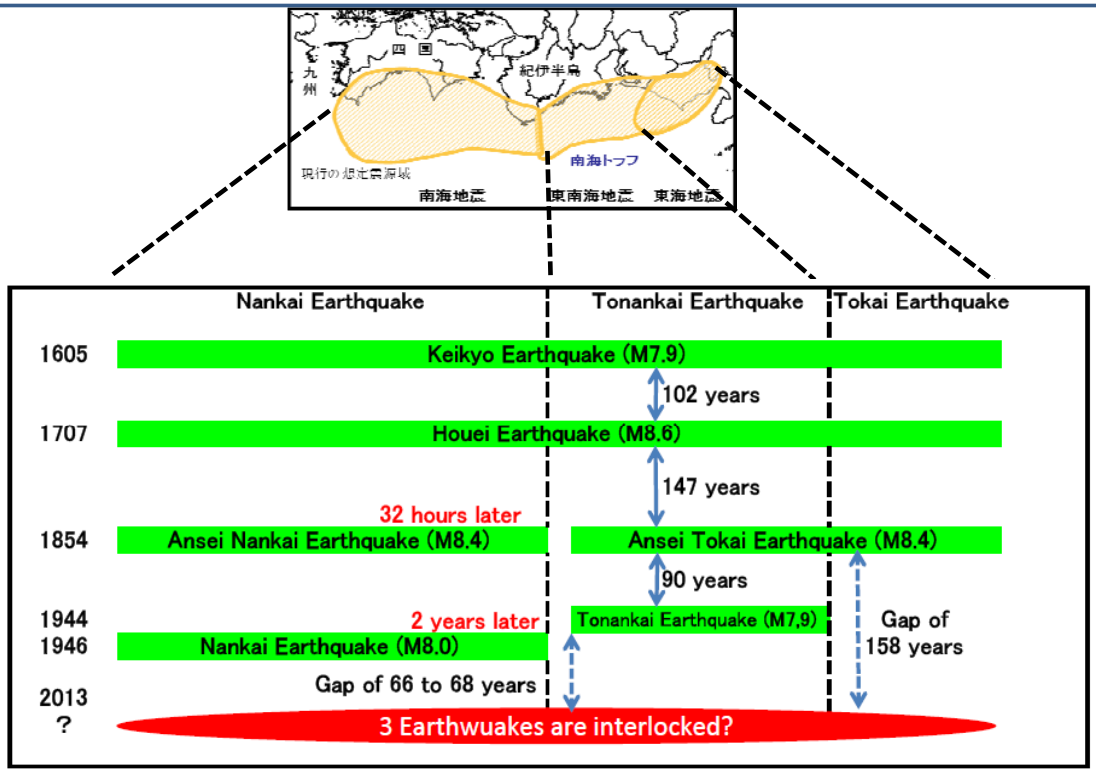
Wide-area Medical Service



*DMAT: Disaster Medical Assistance Team

Large Earthquakes in the Nankai Trough Area Since 1600

Large earthquakes occur roughly every 100 to 150 years



Past Earthquakes Reviewed by the Central Disaster Management Council

Past earthquakes reviewed by the Central Disaster Management Council

1. Repeated occurrence
2. High ratio of occurrence and highly imminent
   - Predicted to occur within the next 100 years
   - Excluded if active fault earthquakes occurred within the past 500 years
3. Confirmed in written records as having a significant impact
4. Predicted magnitude – 7 to 8
5. Impact on economic, social and critical national operations

⇔

Earthquakes studies

Trench-type earthquakes

(1) Tokai earthquake (M8.0)

(2) Tonankai, Nankai earthquakes（M8.6)

(3) Japan oceanic trench, Chishima trench earthquakes（M7.6 to 8.6）

Inland earthquakes

(4) Tokyo inland earthquake（M6.9 to 7.5）

(5)Chubu-area, Kinki-area inland earthquakes（M6.9 to 8.0）

⇕

Great East Japan Earthquake March 11, 2011

Magnitude 9.0 which was not expected near Japan	Breadth and origin of seismic wave was unprecedented since records have been kept	Tsunami height far exceeded expectations

Update of Disaster Management Countermeasures

Central Disaster Management Council
Report by the Committee for Technical Investigation on Countermeasures for Earthquakes and Tsunamis Based on the Lessons Learned from the “2011 off the Pacific Coast of Tohoku Earthquake”(September 28th, 2011)

In order to predict earthquakes and tsunamis in the future,
“A study should be conducted of the largest-possible earthquakes and tsunamis by considering the full gamut of possibilities.”

“Even though it may be unrealistic to adequately provide sufficient facilities and equipment to prepare for a massive earthquake and tsunami which may never eventuate, we still need to ensure that we set the assumptions without holding back.”

Disaster Management Countermeasures Updated

Committee for Technical Investigation of Countermeasures for Earthquakes and Tsunamis Based on the Lessons Learned from the "2011 off the Pacific Coast of Tohoku Earthquake"

⇒ **Update of all disaster management countermeasures based on reviews and lessons learned**

Vision for predicting future tsunamis in order to establish tsunami countermeasures

Two types of tsunamis expected in the future

The largest possible tsunami which will be infrequent but cause widespread damage

Establish comprehensive tsunami countermeasures which prioritize human life by considering the best possible evacuation routes and employ every possible means

Tsunamis with low wave height but high frequency cause serious damage

Upgrade seawalls, save human lives, protect citizen's assets, stabilize economic activities within affected communities and secure manufacturing bases

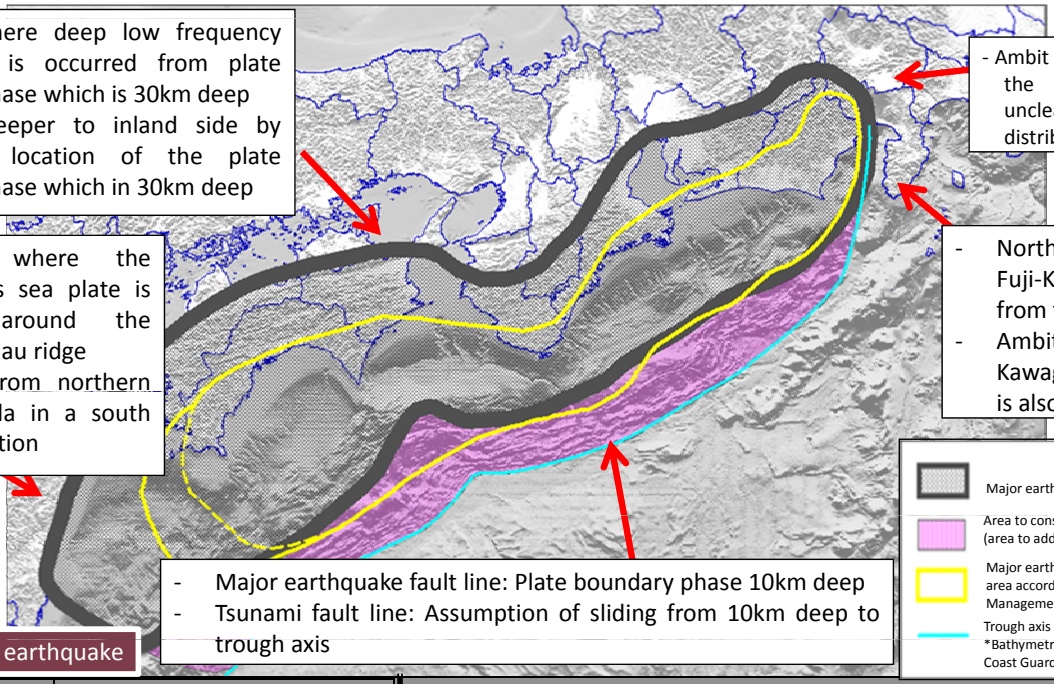
Predictions for the Largest Possible Earthquake and Tsunami Originating from the Nankai Trough

- Ambit where deep low frequency earthquake is occurred from plate boundary phase which is 30km deep
-Expands deeper to inland side by fixing the location of the plate boundary phase which in 30km deep

- Ambit where the figure of the plate becomes unclear from hypocenter distribution

- Ambit where the Philippines sea plate is thicker around the Kyusyu-Palau ridge
- Extends from northern Hyuga-nada in a south west direction

- Northern margin of Fuji-Kawaguchi fault from trough axis
- Ambit of Fuji-Kawaguchi fault line is also covered



- Major earthquake fault line: Plate boundary phase 10km deep
- Tsunami fault line: Assumption of sliding from 10km deep to trough axis

Magnitude of earthquake

	Tsunami fault model	Major earthquake fault model	2011 Pacific coast of Tohoku Earthquake	2004 Sumatra Earthquake	2010 Chile midland Earthquake	Major earthquake fault area Central Disaster Management Council(2003)
Area	**Approx.140,000km^2**	**Approx.110,000km^2**	Approx. 100,000km^2 (approx.500km × 200km)	Approx.180,000km^2 (approx.1200km × 150km)	Approx.60,000km^2 (approx.400km × 140km)	Approx.61.,000km^2
Moment Magnitude Mw	**9.1**	**9.0**	9.0 (Meteorology Agency)	9.1 (Ammon et al., 2005) 9.0 (Chronological Scientific Table)	8.7 (Pulido et al., in press) 8.8 (Chronological Scientific Table)	8.7

Areas of Serious Impact and Damage

1. House and building damage by
   - 1.1. Tremor
   - 1.2. Liquefaction
   - 1.3. Tsunamis
   - 1.4. Rapid landslides
   - 1.5. Earthquake fires

2. Occurrence of fallen objects
   - 2.1. Fallen fences and vending machines
   - 2.2. Other fallen objects

3. Casualties due to
   - 3.1. Building collapse
   - 3.2. Tsunamis
   - 3.3. Rapid landslides
   - 3.4. Fire
   - 3.5. Falling fences , vending machines and other objects
   - 3.6. Moving and falling indoor and outdoor objects
   - 3.7. Entrapment (cannot self escape)
   - 3.8. Missing persons from tsunami damage

4. Damage to essential services
   - 4.1. Water supply
   - 4.2. Sewage
   - 4.3. Electricity
   - 4.4. Communication
   - 4.5. Gus（piped town gas）

5. Transportation facility damage
   - 5.1. Roads (highways, local roads)
   - 5.2. Railways
   - 5.3. Ports
   - 5.4. Airports

Areas of Serious Impact and Damage

6. Effect on human life
   - 6.1. Evacuees
   - 6.2. People who cannot return home
   - 6.3. Supply chain failure
   - 6.4. Medical services required
   - 6.5. Health and hygiene, epidemic prevention, handling of bodies, etc.

7. Debris disposal
   - 7.1. Disposal of large volumes of debris

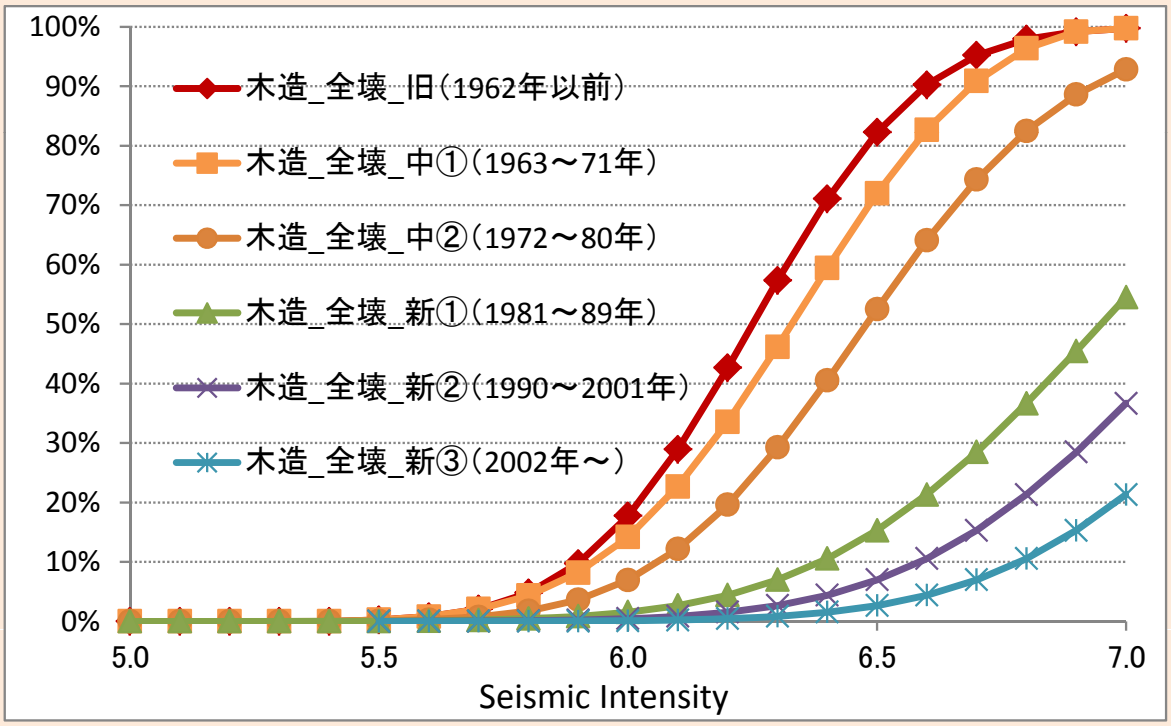
8. Other issues
   - 8.1. Entrapment in elevators
   - 8.2. Long lasting aftershocks
   - 8.3. Road closures
   - 8.4. Falling rocks and cars buried by landslides
   - 8.5. Road accidents
   - 8.6. Railroad accidents
   - 8.7. People requiring support
   - 8.8. Deaths caused by the earthquake disaster
   - 8.9. Developed land with structures
   - 8.10. Protection of dangerous goods and industrial facilities
   - 8.11. Crowded public areas
   - 8.12. Underground shops and subways
   - 8.13. Cultural assets
   - 8.14. Isolated villages
   - 8.15. Disaster emergency measures, etc.
   - 8.16. Dam overflow, storage reservoirs, etc.
   - 8.17. Long-term flooding through ground subsidence
   - 8.18. Multi-faceted disaster
   - 8.19. Time lag earthquakes
   - 8.20. Damage to fishing trawlers, vessels and related facilities
   - 8.21. Law and order

9. Economic loss
   - 9.1. Damaged assets, etc.
   - 9.2. Reduced production and services
   - 9.3. Effect of traffic restrictions
   - 9.4.Preliminary cost of disaster prevention to minimize the impact of the disaster

Estimate Damage ①

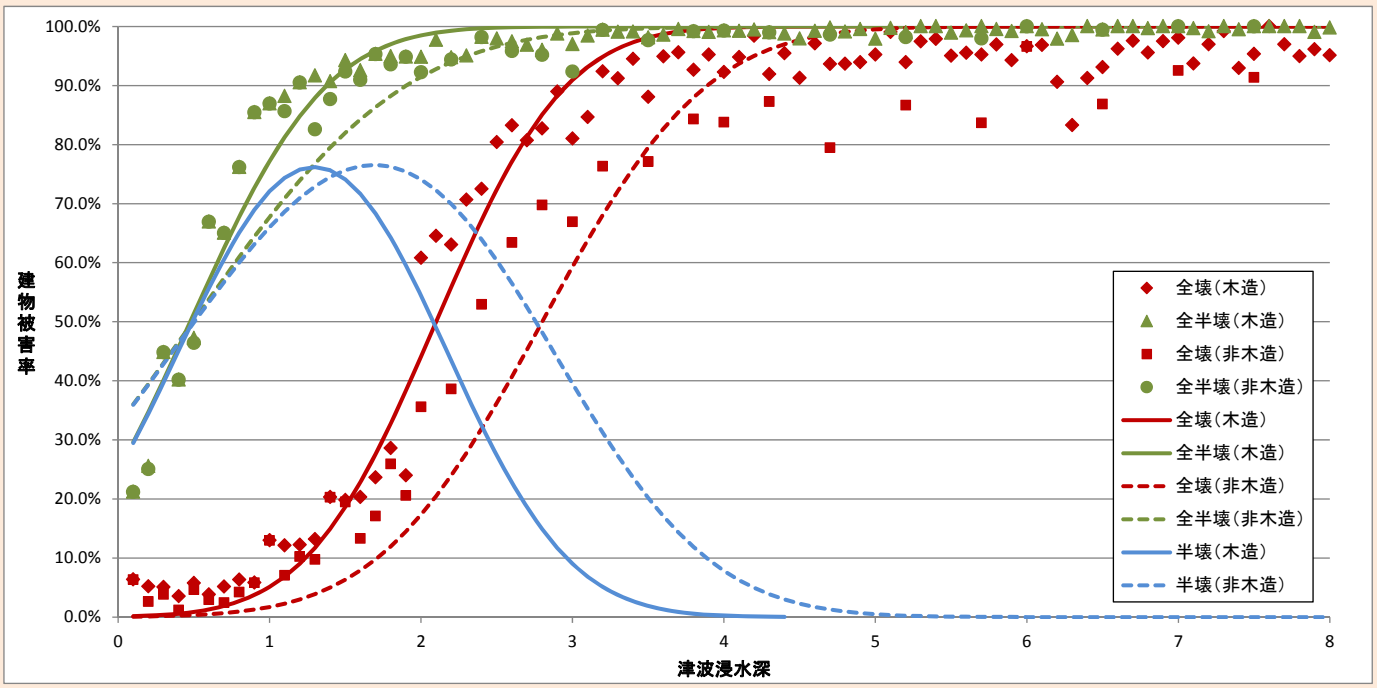
Building damage by Shaking

Ratio of completely destroyed



Estimate likely damage ①

Building damage by tsunamis



Submerge Level – Rate of collapse

Estimate likely damage ②

Deaths by tsunamis　　How evacuate earlier ?

	Evacuation Rate		
	Quick Evacuation	Evacuation after anything to do	Pressure Evacuation
All people evacuate quickly	100%	0%	0%
High early evacuation rate Push each other	70%	30%	0%
High early evacuation rate	70%	20%	10%
Low early evacuation rete	20%	50%	30%

- Quick Eva.　：　5 minutes after (daytime)　10 minutes (night)
- Do anything　：15 minutes after (daytime)　20 minutes (night)
- Pressure Eva.：Start after tsunami reach

Estimated damage　Buildings

The most damaged case in Tokai Region

Earthquake fault (land side)　Tsunami fault (①)

item		Winter/night	Summer/daytime	Winter/evening
Tremor		1,346,000		
Liquefaction		134,000		
Tsunami		146,000		
Landslide		6,500		
Fire	Wind : normal	155,000	194,000	682,000
	Wind : 8 m/s	191,000	230,000	750,000
Total	Wind : normal	1,787,000	1,826,000	2,314,000
	Wind : 8 m/s	1,823,000	1,862,000	2,382,000

Estimated damage　Deaths

The most damaged case in Tokai Region

Earthquake fault (land side)　Tsunami fault (①)

Tremor		82,000	37,000	59,000
Tsunami	High rate Early	117,000	68,000	70,000
	Low rate Early	230,000	195,000	196,000
Landslide		600	200	400
Fire	Wind : normal	8,600	5,200	21,000
	Wind : 8 m/s	10,000	5,900	22,000
Total	Wind : normal	208,000 ～321,000	111,000 ～ 237,000	151,000 ～ 277,000
	Wind : 8 m/s	209,000 ～ 323,000	111,000 ～ 238,000	152,000 ～ 278,000

Comparison of Actual vs. Predicted Damage

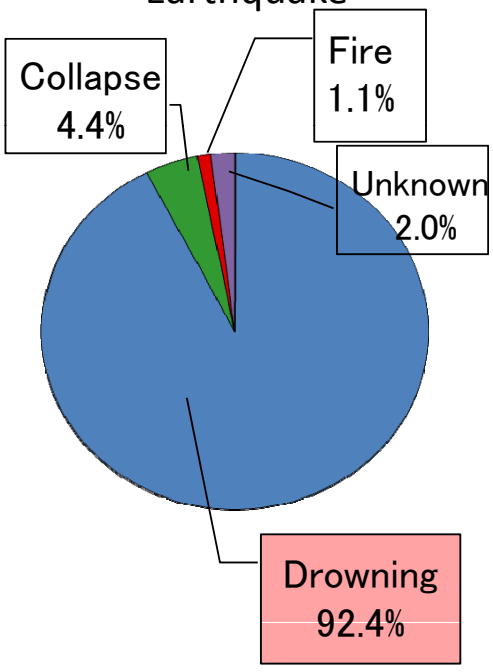
Comparison Between the Pacific Coast of Tohoku Earthquake and a Predicted Large-Scale Nankai Trough Earthquake

	Magnitude (*1)	Wetted surface area	Population of wetted area	Dead and missing	Building damage (completely destroyed)
Pacific Coast of Tohoku Earthquake	9.0	561km2	Approx. 620,000	Approx. 18,800(*2)	Approx. 130,400(*2)
Large-Scale Nankai Trough Earthquake	9.0(9.1)	1,015km2(*3)	Approx. 1,630,000(*3)	Approx. 323,000(*4)	Approx. 2,386,000(*5)
Magnification ratio		Approx. 1.8 times	Approx. 2.6 times	Approx. 17 times	Approx. 18 times

*1 : Inside ( ) is Mw of tsunami
*2 : Reported by Disaster Headquarters June 26th, 2012
*3 : Assumed wetted surface area when seawalls and floodgates function properly during earthquake motion.
*4 : Damage when earthquake motion is landward, tsunami level is 1, it is midnight in winter , and the wind speed is 8m/s.
*5 : Damage when earthquake motion is landward, tsunami level is 5, it is the evening in winter and wind speed is 8/s.
*6 : Damage if it is 5am.
*7 : Damage if it is 6pm.

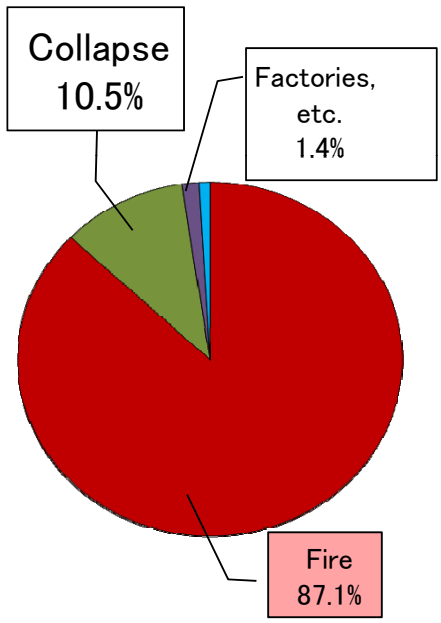
Cause of Death Due to a Large-Scale Earthquake

Great East Japan Earthquake



Source : Metropolitan Police Department

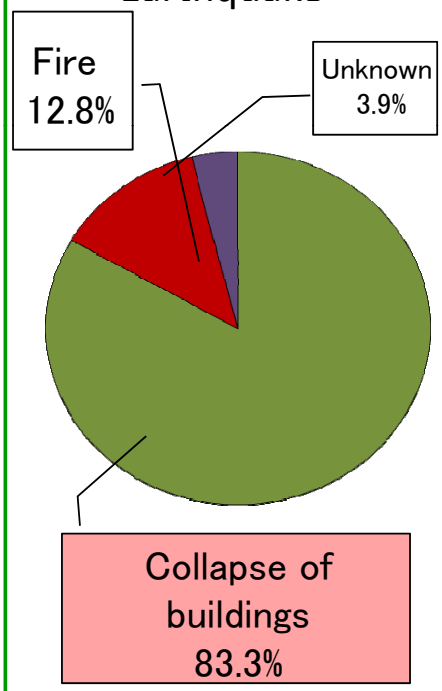
Great Kanto Earthquake



Dead and missing persons : 105,385

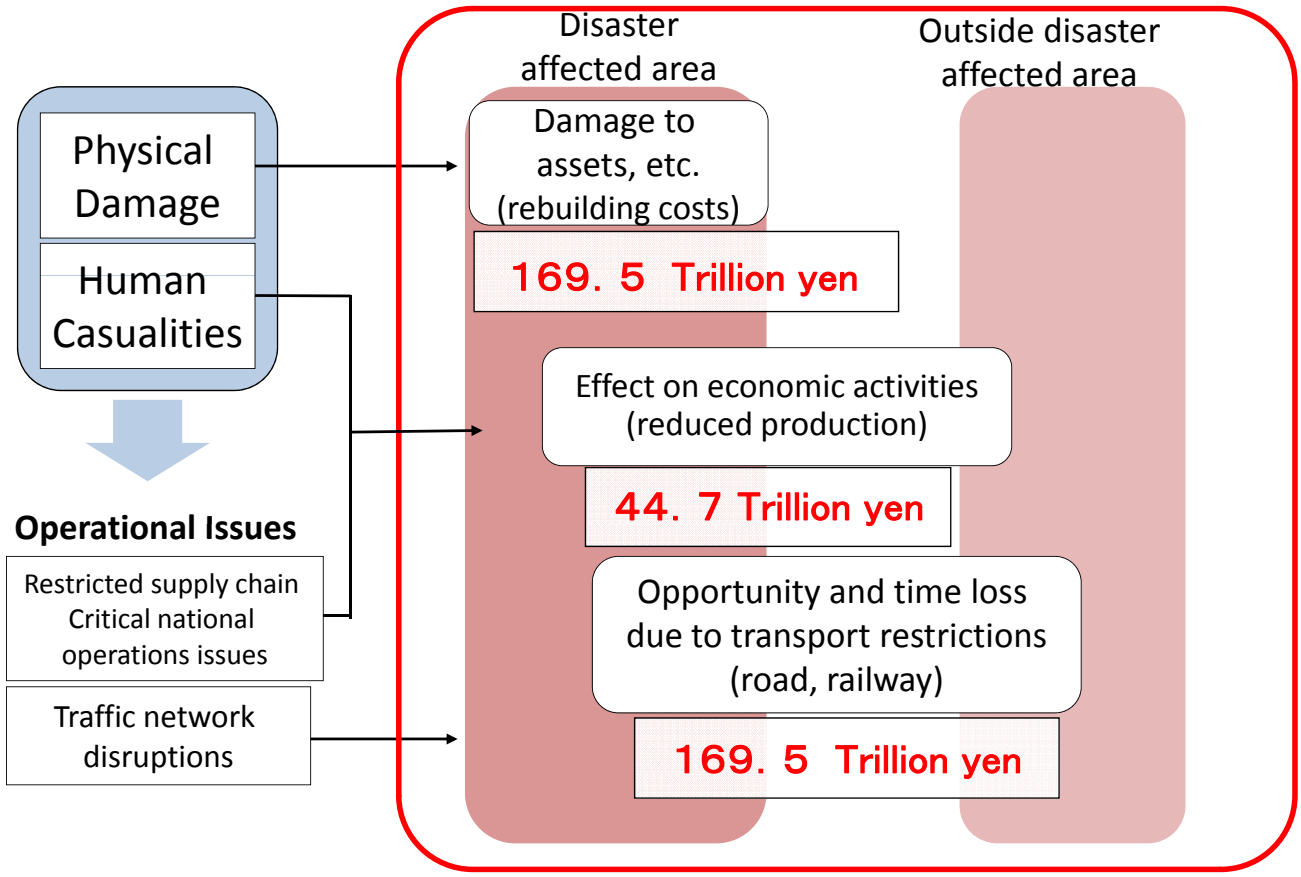
Source : Japan Association for Earthquake Engineering

Great Hanshin-Awaji Earthquake



Source : Autopsy statistics in Kobe city

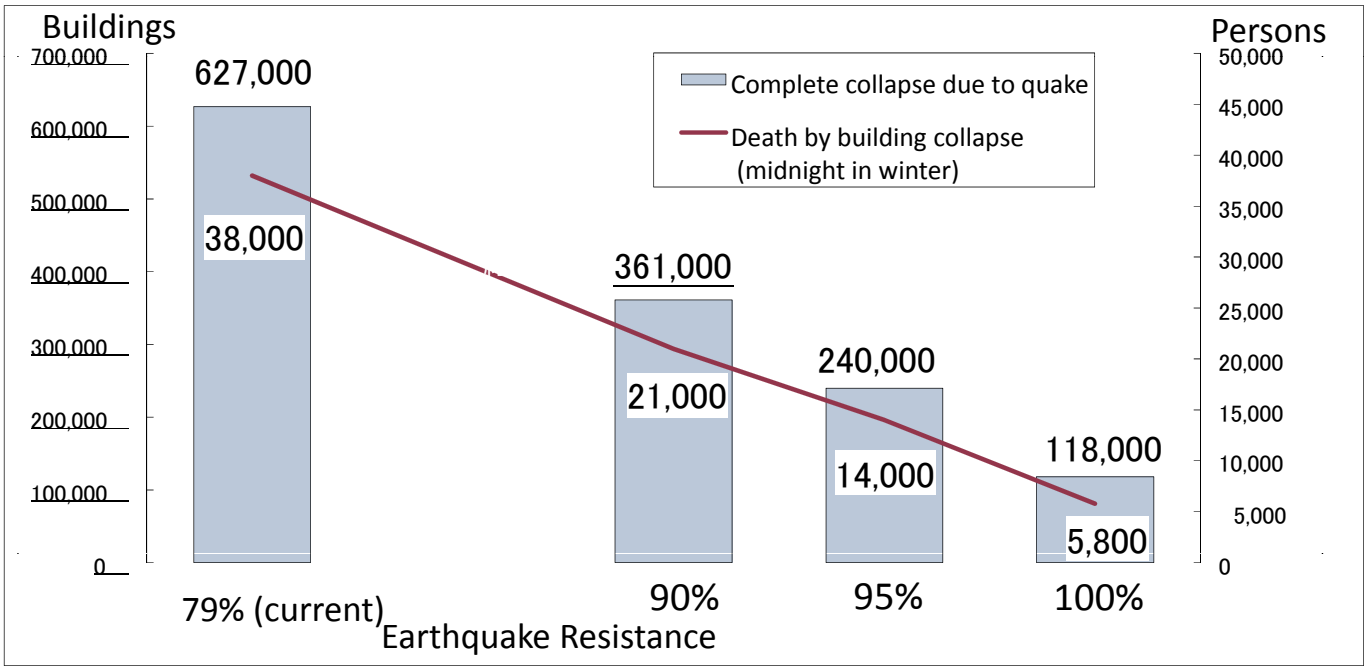
Predicted Damage



Effect of Disaster Preparedness

(1) Earthquake-proofing buildings

- The average ratio of earthquake-proof houses is 79% in Japan (2008)
- Loss reduction is estimated by assuming buildings constructed using the old quake-resistance standard are upgraded or have anti-seismic reinforcement retrofitted.



Effect of Tsunami Preparedness

Quick start to Evacuation, Evacuation places (buildings)

242,000

Seawalls and floodgates
Didn't function properly

[Low early evacuation rate] [High early evacuation rate] [Quick start of early evacuation]

242,000 → 109,000 → 85,000

Effective use of evacuation buildings

157,000 → 70,000 → 52,000

Extent of Damage (Heavily Damages Areas)

Extent immediately Following the disaster

■Damage to essential services

Electricity :	Blackout in 90% of the area
Landline telephones :	90% of telephones not working due to cable damage, blackouts, etc.
Cellular phones :	20% of base stations non operational. 90% of calls cannot be made due to congestion.
Internet :	20% cannot contact.
Email :	80% cannot connect, however it is much slower.
Water supply and sewage pipes:	90% are out of service.
Piped town gas :	90% are out of service.

■Damage to transport facilities

- Cracks and potholes can be found on many national, prefectural and local roads
- Roads are difficult to drive on due to debris from collapsed buildings
- Highways are closed because of severe damage and require maintenance
- The Shinkansen (bullet train) is completely out of service
- Most conventional transport links are out of service

Emergency Support Following a Disaster⇒Rehabilitation, Reconstruction

Search & rescue activities

☐ Fire fighting

○Dispatch of Self-Defense Force
○Emergency fire crews
○Wide-area emergency support team (incl. police)
○DMAT (disaster medical service)

Dispatch of support agencies

○Dispatch of agencies from central, prefectural and local governments, etc.

Restoration of services

○Communications, electricity, water supply, sewage pipes, piped town gas

Support for evacuees

○Commodity procurement
○Fuel procurement
○Support for volunteering activities
○Securing of temporary housing
○Support for the homeless

Rehabilitation, Reconstruction

○Essential public infrastructure such as roads, ports, etc.
○Public buildings
○Reconstruction of houses, business offices cities.

◆ Opening of roads ◆ Securing major transportation links