Lessons learned from the 2011 Great East Japan Earthquake/Tsunami towards tsunami-resilient communities

Shunichi Koshimura
International Research Institute of Disaster Science (IRIDeS)
Tohoku University
The 2011 Tohoku Tsunami

15:59:24.28

NHK
Topics

• Hazard map
• Coastal defense structure
• Structural vulnerability
• Reconstruction and Land use management
The tsunami was far more extensive than expected!

Source: Cabinet Office of Japan

Sendai city
Fatality: 755
Lesson

Tsunami hazard map helps for understanding risks. However, sometimes the tsunami will be higher and more extensive.

We should change our perception, attitude and norms to risks.
Devastated Seawalls
Lesson

Breakwaters and seawalls can NOT always protect our lives and properties. It’s design should assume overtopping and resiliency.
Devastated coastal communities
Structural vulnerability
Tohoku & Banda Aceh

![Graph showing structural vulnerability comparison between Tohoku Tsunami and Banda Aceh. The graph plots damage probability against flow depth (m).]
Lesson

2 m tsunami flow depth potentially causes severe damage on houses or may devastate.

Over 6 m tsunami flow depth will cause total devastation.

Implication to land use management and tsunami risk evaluation.
Sendai city’s reconstruction plan
Multiple protection to minimize losses
Elevated prefectural road +6m

Coastal Levee 7.2 m

Coastal Levee 4.4 m
How the multiple protection works ...
Implication to land use management and relocation plan in the tsunami affected areas

Areas subject to relocation (Building restriction)

Relocation candidate

Sendai city
Lesson

To build tsunami-resilient community, NEVER forget the memories of disasters and keep it around us.
JMA Tsunami warning issued based on 100,000 cases of database of tsunami simulation, but ...

1st. issue
3 minutes after the quake

2nd. (revised) issue
28 minutes after the quake

Iwate : 3m
Miyagi : 6m
Fukushima:3m

Iwate : 6m
Miyagi : >10m
Fukushima: 6m
Ibaraki : 4m
Chiba : 4m

Revised using offshore tsunami gauge

© JMA
Lesson

Tsunami warning information is to know you are in danger, but it does NOT guarantee your safety. Do NOT wait for official information.
Lessons towards tsunami-resilient community

• Knowing risks
  - Very important to know risks but sometimes the nature is beyond our science and technology.

• Structural vulnerability
  - Breakwaters and seawalls can NOT always protect our lives. It should be designed with assumption of overtopping and destruction.
  - Do NOT rely on coastal protection.
  - Over 2 m tsunami flow depth potentially causes destruction on houses.

• Reliability of information
  - Increase the reliability of tsunami warning towards quick, accurate and robust dissemination. Attitude NOT to rely on official information.
Cause of death

• Underestimated seismic evaluation.
• Hazard map – underestimation of tsunami risks.
• Delay of tsunami warning and evacuation information.
• Blackout and failure of information dissemination.
• Relying on coastal protection.
• Using a car to pickup children and elderly.
• Difficulty in access to evacuation place.
The 2011 Tohoku tsunami disaster

- **Inundation zone**
  - 561 km$^2$ along the Pacific coast of Japan.

- **Fatality**
  - 15,850 people were killed, and 3,281 people are still missing. More than 90% of deaths were caused by drowning and 65% of the dead were over 60 years old.

- **Structural damage**
  - 128,581 buildings/houses were washed-away or collapsed.

- **Tsunami debris**
  - 23 mil. ton

- **Economic losses**
  - 16 to 25 trillion JPY, $\frac{1}{4}$ of annual budget of Japan.