

The impact of the 2011 Tohoku earthquake tsunami disaster; implications to the recovery and reconstruction

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The 2011 Tohoku Tsunami Sendai



The 2011 Tohoku Tsunami Onagawa



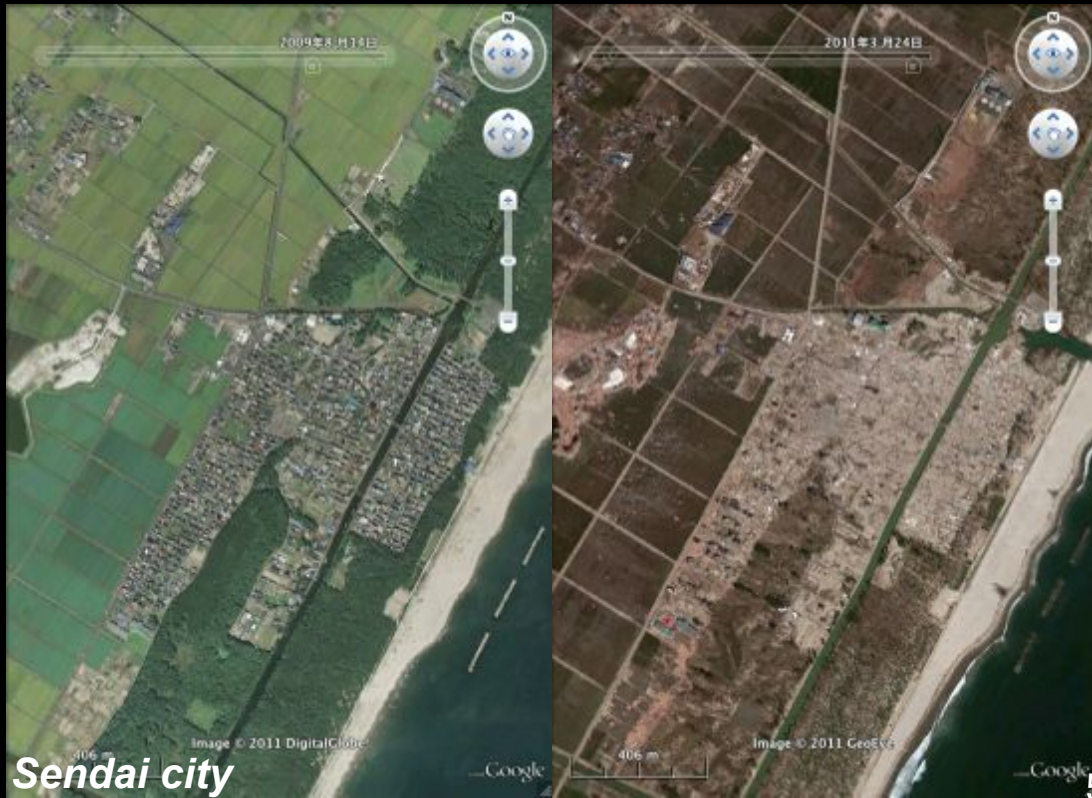
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Topics Lessons on ...

- Structural damage and vulnerability
- Coastal defense structures
- Reconstruction and Land use management

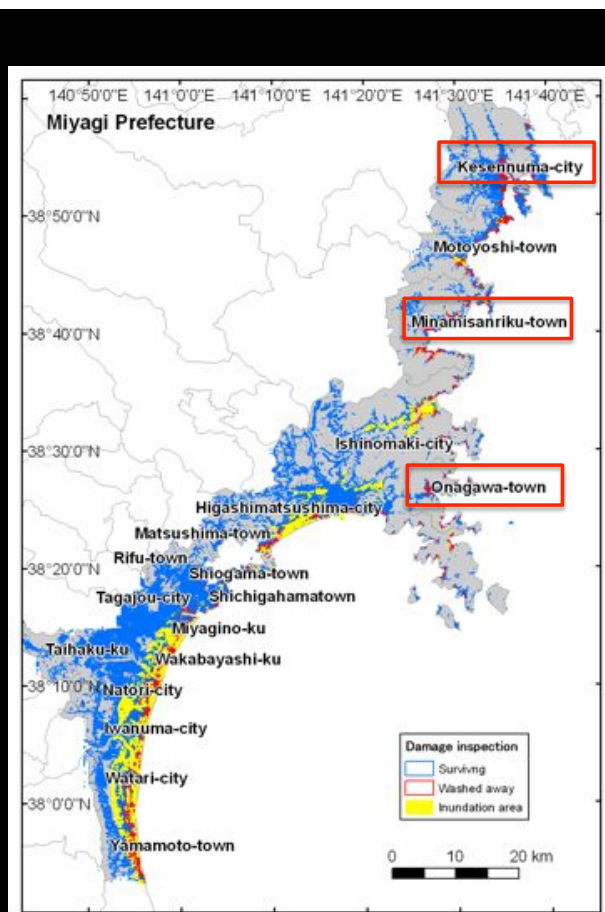
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Devastated coastal communities



Sendai city

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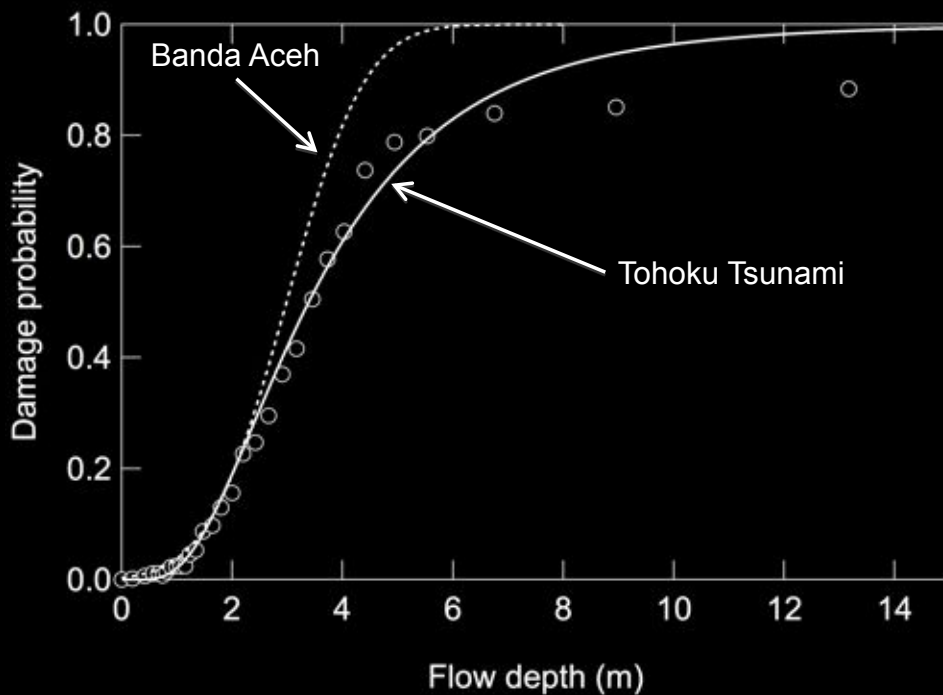


Proportion of damage in each town/city

Town/city	Exposed structure	Washed-away	Damage Probability (%)	Fatality ratio (%)
Kesen-numa	13951	8047	58	3.5
Minamisanriku	6665	5418	81	6.3
Ishinomaki	62440	12521	20	3.5
Onagawa	4607	3459	75	12.2
Higashimatsushima	16860	3171	19	3.3
Matsushima	695	14	2	0.05
Shiogama	8995	373	4	0.11
Shichigahama	3253	1120	34	0.82
Tagajo	6310	226	4	1.1
Sendai	13721	4329	32	2.4
Natori	5530	2810	51	8.1
Iwanuma	5285	1298	25	2.3
Watari	8143	2059	25	1.9
Yamamoto	5373	2802	52	7.7

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Structural vulnerability Tohoku & Banda Aceh



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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.

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Devastated Seawalls



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Tsunami breakwater in Kamaishi
Length : 2km, Surface height above sea level : 8m, Width : 20m



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Lesson

Breakwaters and seawalls can NOT always protect our lives and properties. It's design should assume overtopping and resiliency.

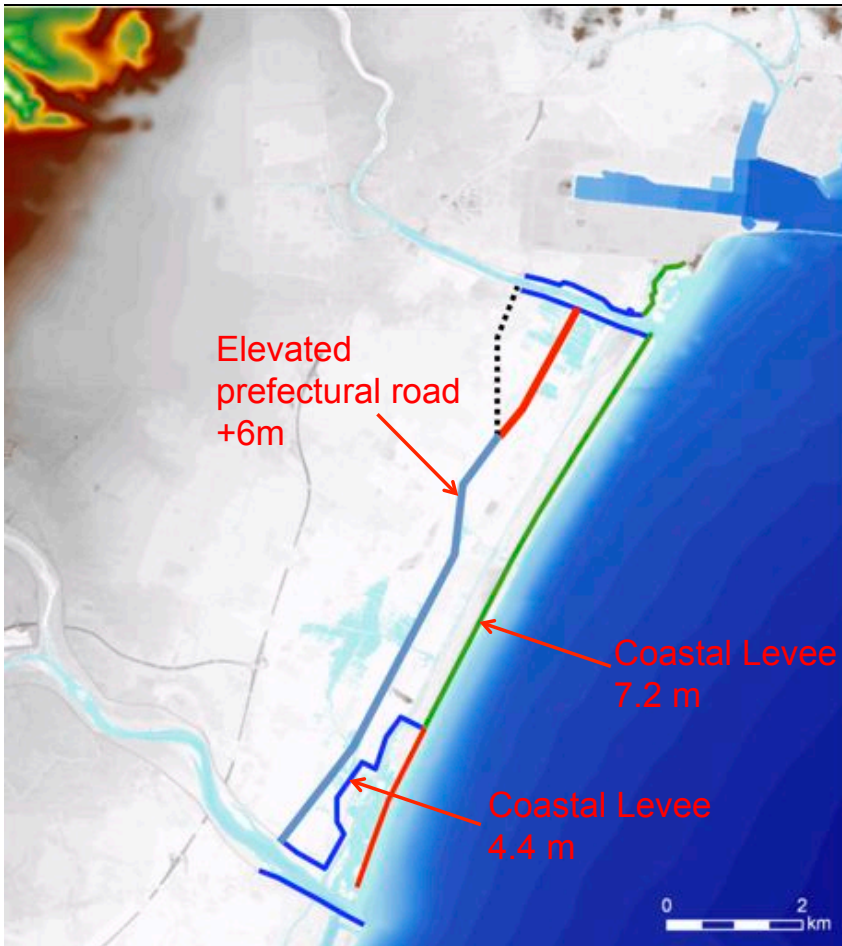
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Sendai city's reconstruction plan Multiple protection to minimize losses



Sendai city

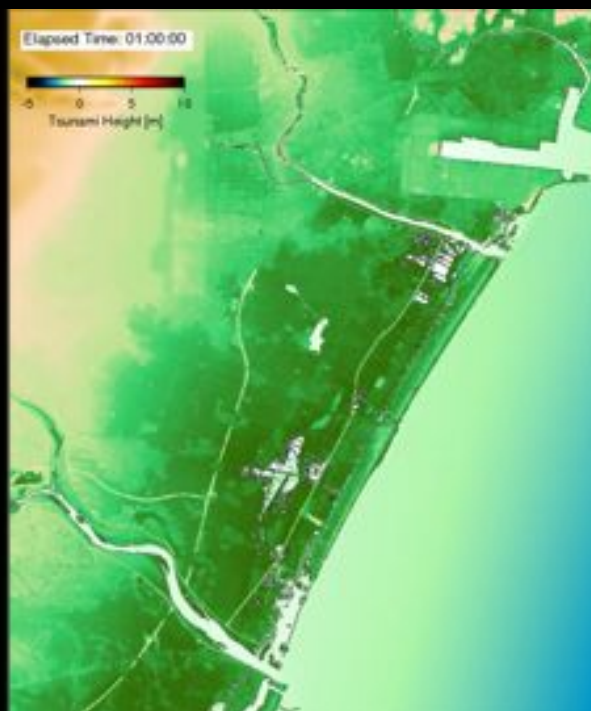
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Final plan in Sendai city

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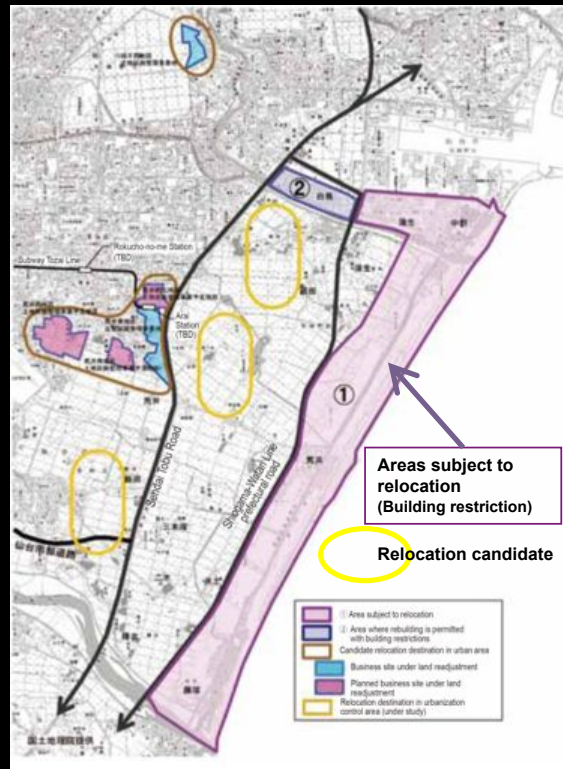
How the multiple protection works ...



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Implication to land use management and relocation plan in the tsunami affected areas

Sendai city



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Relocation Toni-Hongo, Kamaishi [Iwate Pref.]

The 1933 Showa tsunami
(50 days after the event occurred)



Source : B.E.R.I



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1934



2009



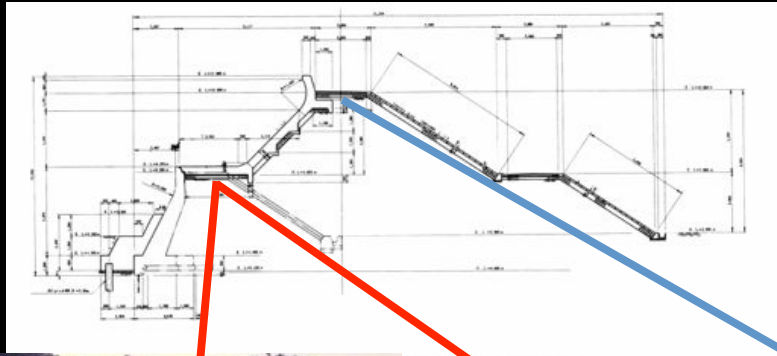
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2011



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The sea wall was build in 1974 and 1999



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Photo by Prof. N. Shuto

After the sea wall was built...



- Before 1960
- Until 1974
- Until 1999

M. Kumagai and N. Shuto

Lesson

Building sea walls does not always contribute to increasing tsunami-resiliency (resilient and sustainable community).

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Summary

- Over 2 m tsunami flow depth potentially causes destruction on houses.
- Multi-story (high-rise) reinforced and robust concrete buildings can withstand and be used for vertical evacuation. But the regulation should be reconsidered.
- 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.
- Building sea walls does not always contribute to increasing tsunami-resiliency.

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Tsunami countermeasures in Japan

1. Coastal protection

Building seawalls and break waters to protect life and property

2. Building tsunami-resilient community

Urban planning, land use, relocation.

3. Emergency response and preparedness

Tsunami warning, evacuation (horizontal and vertical), public education.