Global and future perspectives of tsunami disaster mitigation

- Impacts of sea level rise on tsunami hazards
- Contributions of Japanese tsunami engineering

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Tsunami Engineering Laboratory
International Research Institute of Disaster Science (IRIDeS)
Tohoku University
Sendai, Japan
Damaging tsunamis that exceeded 2 m can be seen virtually everywhere, especially along the Pacific Rim including 1700 Cascadia (M9.0), 1755 Lisbon (M8.5), 1833 SW Sumatra (M8.3), 1868 Peru (M8.3), 1906 Ecuador (M8.8) and 1960 Chile (M9.5).

Only two major events, the 2004 Indian Ocean (M9.3) and Great East Japan (M9.0), classified as recent damaging tsunamis that exceeded 2 m and caused global impact meanwhile no major damaging tsunami in the east Pacific and Atlantic Ocean.

This observation demonstrates the importance of assessing or recognizing the hazards based on historical events beyond recent experiences.
Application for regional tsunami risk perspective

Distribution of ports and their network

Future tsunamis in the South China Sea

Damage port from each scenario

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Port name</th>
</tr>
</thead>
<tbody>
<tr>
<td>M85_01</td>
<td>Kaohsiung</td>
</tr>
<tr>
<td>M85_02</td>
<td>Kaohsiung</td>
</tr>
<tr>
<td>M87_01</td>
<td>Kaohsiung, Shantou</td>
</tr>
<tr>
<td>M87_02</td>
<td>Kaohsiung</td>
</tr>
<tr>
<td>M87_03</td>
<td>Kaohsiung, Shantou</td>
</tr>
<tr>
<td>M89_01</td>
<td>Kaohsiung, Shantou, Yantian</td>
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<tr>
<td>M89_03</td>
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<td>M89_05</td>
<td>Kaohsiung, Shantou, Yantian</td>
</tr>
<tr>
<td>M89_06</td>
<td>Kaohsiung, Shantou, Yantian</td>
</tr>
<tr>
<td>M89_08</td>
<td>Manila</td>
</tr>
<tr>
<td>M90_01</td>
<td>Kaohsiung, Shantou, Yantian, Hong Kong</td>
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<tr>
<td>M90_02</td>
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<td>Kaohsiung, Shantou, Yantian</td>
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<td>M90_06</td>
<td>Kaohsiung, Manila</td>
</tr>
<tr>
<td>M90_07</td>
<td>Kaohsiung, Manila</td>
</tr>
</tbody>
</table>
Non-seismic tsunami: Submarine landslide

2018 Sulawesi Island (Palu) tsunami

Pakoksung et al., 2019 PAGEOPH
Non-seismic tsunami: Aerial landslide

2018 Sunda Strait tsunami

(a) image on December 17, 2019
(b) image on December 30, 2018

Pakoksung et al., 2020 Geoscience Letters
Non-seismic tsunami: Volcanic eruption

The 15 January 2022 Huga Tonga Hunga Ha’apai volcanic eruption

Air pressure generated tsunami that arrived Japan earlier than expected
Impact of sea level rise (SLR) on tsunami

SLR → Less significant from bottom friction

Normal sea level

Inundation map

Impact of sea level rise (SLR) on tsunami

Inundation map

Increase of flow depth (left) inundation area (right)

Cross section of tsunami inundation
Impact of sea level rise (SLR) on tsunami

SLR impact on the 2011 Great East Japan Earthquake and Tsunami?

90 lives of children and teachers might not be safe

Source: TBS TV
Impact of sea level rise (SLR) on tsunami

SLR impact on the 2011 Great East Japan Earthquake and Tsunami?

Inundation distance will be larger
Flow depth will be larger
→ More casualty and damage

Source: TBS TV
Previous studies: Banda Aceh

Coupling sea-level rise with tsunamis: Projected adverse impact of future tsunamis on Banda Aceh city, Indonesia

Tursina a,b, Syamsidik a,b,c,d, Shigeru Kato a,c, Mohammad Affuddin a,c
Previous studies: Macau

A modest 0.5-m rise in sea level will double the tsunami hazard in Macau

Linlin Li¹, Adam D. Switzer¹,²*, Yu Wang¹,³, Chung-Han Chan¹, Qiang Qiu², Robert Weiss⁴

SCIENCE ADVANCES | RESEARCH ARTICLE

ENVIRONMENTAL STUDIES
Quantitatively assessed changing of the maximum inundation depth and damage probability as increasing of sea level rise.
Japan case study: SLR impact on total loss

- Indirect Loss / Total Loss: 63~66%
- In the case of 0m sea level rise, Japan trench model: 440 bil. USD, Outer rise model: 520 bil. USD
- In the case of 1m sea level rise, Japan trench model: 70% up, Outer rise model: 22% up

The Japan trench model is more susceptible to SLR.

$M_w$ 9.0 (Japan trench model)
$M_w$ 8.7 (Outer rise model)
Japan case study: SLR impact (by sector)

Economic Losses: Agriculture < Service < Manufactures

- Manufactures are concentrated in the coastal areas.
- Agriculture has a low unit cost.

In the case of 1m sea level rise:
- Japan trench model: 67~74% up
- Outer rise model: 13~26% up

The Japan trench model is more susceptible to SLR.

\[ M_w \ 9.0 \text{ (Japan trench model)} \]
\[ M_w \ 8.7 \text{ (Outer rise model)} \]
In particular, the Japan Trench model shows a 173% increase in the Kanto region due to a 1 m rise in sea level.

The Kanto region is home to the capital, Tokyo, and is the economic center of Japan.

Therefore, the increase in direct damage in the Kanto region is thought to have resulted in significant indirect damage.

Protecting economically important cities will reduce indirect damage to other areas and lead to a reduction in damage to the country as a whole.
Scientific collaboration
Building damage characteristics

Characteristics of building fragility curves for seismic and non-seismic tsunamis: case studies of the 2018 Sunda Strait, 2018 Sulawesi–Palu, and 2004 Indian Ocean tsunamis

Elisa Lahcène1, Ioanna Ioannou2, Anawat Suppasri3, Kwanchaisak Pakoksung4, Ryan Paulik5, Syamsidik Syamsidik6, Frederic Bouchette7, and Fumihiro Imamura8

1Geosciences Montpellier, Montpellier University II, Montpellier, France
2Department of Civil, Environmental & Geomatic Engineering, University College London, United Kingdom
3International Research Institute of Disaster Science, Tohoku University, Sendai, Japan
4National Institute of Water and Atmospheric Research (NIWA), Wellington, New Zealand
5Tsunami and Disaster Mitigation Research Center (TDMRC), Universitas Syiah Kuala, Banda Aceh, Indonesia


Indonesia faced recent tsunamis

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<thead>
<tr>
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<tbody>
<tr>
<td>Tsunami source</td>
<td>Indian Ocean Earthquake</td>
<td>Flank failure of the Anak Krakatau</td>
<td>Subaerial/Submarine landslides</td>
</tr>
</tbody>
</table>

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Scientific collaboration
Multi-layered countermeasure

With Syiah Kuala University (Indonesia)

Systematic Evaluation of Different Infrastructure Systems for Tsunami Defense in Sendai City
by KwanChai Pakoksung, Anawat Suppasri, and Fumihioko Imamura

International Research Institute of Disaster Science, Tohoku University, 468-1 Aramaki-Aza, Aoba-ku, Sendai 980-0845, Japan
* Author to whom correspondence should be addressed.

Geosciences 2018, 8(5), 173; https://doi.org/10.3390/geosciences8050173

Assessing the tsunami mitigation effectiveness of the planned Banda Aceh Outer Ring Road (BORR), Indonesia

Syaamida, T., Turaino, A., Suppasri, A., Al’ala, M., Mumtaz, L., and K. Comfort

1 Tsunami and Disaster Mitigation Research Center (TDMRC), Syiah Kuala University, Gampus Pie, Banda Aceh 23233, Indonesia
2 International Research Institute of Disaster Science (IRIDeS), Tohoku University, Aramaki-Aza-Aoba 4-6-1, Aoba-ku, Sendai 980-0845, Japan
3 Civil Engineering Department, Syiah Kuala University, Banda Aceh 23111, Indonesia
4 Graduate School of Public International Affairs, University of Pittsburgh, Pittsburgh, USA


Figure 10. Maximum tsunami wave depths based on the 9.15 Mw earthquake without BORR (a) and with BORR (b). The simulations are shown for the land use type before the 2004 Indian Ocean tsunami.
Scientific collaboration
Tsunami sediment transport modeling

With Chulalongkorn University (Thailand)
Masaya et al (2020) Natural Hazards and Earth System Sciences
Masaya et al (2020) Coastal Engineering (JSCE)
Masaya et al (2021) Coastal Engineering (JSCE)

Elapsed time: 02:19:30

Tsunami height

Before

After

Water level(m)

Cs concentration(%)
Scientific collaboration
Disaster mitigation class in Hawaii
Collaboration with Thai media and local organization

Thai PBS every Saturday 11:00-11:30

Joint field survey of Japanese researcher, TMD, Thai PBS

International workshop

New exhibition

Tsunami museum
Khao Lak
Building Sustainable System for Resilience and Innovation in Coastal Community “BRICC”

1. Development of coastal monitoring system
   Nobuhito Mori (Kyoto University)
   Mohammad Farid (ITB)

2. Coastal multi-hazard risk assessment
   Anawat Suppasri (Tohoku University)
   Abdul Muhari (BNPB)

3. Development of Eco-DRR/Nature-based solution
   Kojiro Suzuki (PARI)
   Djati Mardiatno (UGM)

4. Development of Inclusive and Evidence-based Decision Support Platform
   Taro Arikawa (Chuo University)
   Dicky Pelupessy (UI)
• **Project objective**
  – Multi-hazard assessment of coastal areas by applying the latest monitoring and modeling techniques
  – Establish a coastal defense function methodology using Eco-DRR/Green Infrastructure
  – Establish an integrated platform for natural adaptive coastal defense technologies
  – 5-10 years later: Creative social implementation of coastal areas in harmony with disaster risk reduction, environment and economy

• **SDGs**
  – **Goal 11:** SUSTAINABLE CITIES AND COMMUNITIES
  – **Goal 9:** INDUSTRY, INNOVATION AND INFRASTRUCTURE
  – **Goal 13:** CLIMATE ACTION
  – **SENDAI Framework:** Global Target ABCEFG
Integrated collaboration through SATREPS

Resilient Coastal Community

Theme 1: Monitoring
- Boundary conditions
- Validation data

Theme 2: Hazard assessment
- Hazard intensity

Theme 3: Green infrastructures

Theme 4: Social implementation
- Realtime data
- Disaster Information
- Social demand
- Hazard map
- Disaster risk reduction
Site 1
Bali

- Sever coastal erosion
- Important for tourism
- Potential multi-coastal hazards

Sub-site
East Kalimantan

Sub-site
Pangandaran

Site 2
Ambon

- Developing area (6.9%/yr population increase)
- 15 rivers with mangroves
- Potential large earthquake and tsunami

Integrated collaboration through SATREPS
Collaboration with UN organizations

1. UNDRR: World Tsunami Awareness Day, World Tsunami Museum Conference
2. UNDP: School project, Global Center for Disaster Statistics
3. UNESCO - IOC: Evaluation of tsunami in South China Sea
4. UNITAR: Capacity building of community leaders
Tsunami evacuation in schools

Collaboration with UNDP

Tsunami evacuation drill in schools

Evacuation drill planning in schools

Tsunami information poster
Tsunami evacuation during COVID-19 pandemic

Collaboration with UNDRR · UNDP

General information

- At 2 metres: destruction of wooden houses
- At 1 metre: vehicles float and drift away
- At 0.5 metres: loss of human stability

Layout of evacuation shelter

Post-COVID evacuation

Thank you for your kind attention
Heritage, or Just Garbage?

How Private Documents Can Help Disaster Survivors and Communities: Stories from Northeastern Japan, 2011

J.F. MORRIS and KAMYAMA Michiko
Visiting Professors
International Research Institute of Disaster Science,
Tohoku University, Sendai, Japan.

Photo compliments of SATO Shūichi
Disaster Hits: 11th March, 2011, Miyagi Prefecture

Triple disaster of earthquake, tsunami & nuclear reactor explosion hit the northeast coast of Honshu

Map 1

Map 2

Map 3

We live here!

http://www.jma.go.jp/en/tsunami/focus_04_20110311145000.html Japan Meteorological Agency

http://www.jma.go.jp/en/tsunami/focus_04_20110311145000.html Japan Meteorological Agency

https://maps.gsi.go.jp/multi/index.html#11/38.310413/140.984802&base=pale&ls=pale%7Chillshademap%2C0.1%7Cchuki_eng&blend=0&disp=111&lcd=chuki_eng&vs=c1

Geospatial Information Authority of Japan
Our city before and after the tsunami

Before the tsunami

17th April 2011

We live here

We still live here!
How things looked from the ground

Rubble, more rubble, and debris

Relief centres filled beyond capacity

http://infra-archive311.jp/data/pic/305436.jpg

Tohoku Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism
Quick recovery requires a quick clean-up...

• The first step in regaining normalcy required that all debris be speedily disposed of.
• But what is the dividing line between ‘debris,’ ‘garbage’ and ‘heritage’

????? Why does ‘heritage’ come up here ?????
An Unlikely Couple: ‘Heritage’ & DDR

Getting down to fundamentals:
• Are culture, heritage, and cultural heritage relevant to DDR?
• Can culture, heritage, and cultural heritage save lives?

The answer to both questions is a strongly affirmative ‘YES’

A Copernican change occurred between Hyōgo 2005 and Sendai 2015: From ‘culture of resilience’ to ‘cultural resilience’
Cultures, Heritage & DDR: Hyōgo Framework 2005

Hyōgo Framework for Action 2005-2015 (HFA) identified 5 priorities

- Priority No. 3  
  *Use knowledge, innovation and education to build a [culture of safety and resilience](#) at all levels*

  Mobilising knowledge, innovation and education to build ‘a culture of safety and resilience’ is listed as a core priority, but neither culture, heritage, nor cultural heritage are identified as an independent variable which can support resilience and drive innovation.

- 2015 Synthesis Report conclusion: the focus of national and international attention must shift from protecting social and economic development against external shocks, to transforming growth and development to manage risks, in a holistic manner.

Culture, Heritage & DDR: Sendai Framework 2015

Sendai Framework for Disaster Risk Reduction 2015-2030 identified 7 Targets and 4 Action Priorities

• Priority 3: Investing in disaster risk reduction for resilience
  29. Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment. These can be drivers of innovation, growth and job creation. Such measures are cost-effective and instrumental to save lives, prevent and reduce losses and ensure effective recovery and rehabilitation.

  ‘Cultural resilience’ can drive innovation, growth and employment, & is cost effective!
  ‘Culture of safety and resilience’ ‘cultural resilience’ (=economic, social & health resilience)

• National and local levels
  30. To achieve this, it is important:
(d) To protect or support the protection of cultural and collecting institutions and other sites of historical, cultural heritage and religious interest;

  ‘Culture’ is embedded in museums etc, and physical sites i.e. Big Heritage
Who/what/how do you define(s) ‘Heritage?’

• Sendai Framework for DDR sees heritage as the Big Heritage enshrined in public museums, libraries and art galleries, and in national sites of memory.

• This kind of heritage is commonly designated as such by local, regional, national or international governments of public institutions, and are often protected by public institutions and/or laws.

• The heritage commonly relates to the memory and identity at regional, national or international levels Big heritage

• But what about the memories of individuals, families or local communities, and the repositories of these memories Little heritage
Japan’s hidden heritage: private documents

Documents held in private hands are estimated to number about 2,000,000,000 items

Photos compliments of SATÔ Daisuke
Heritage salvage after 2011: easier said than done

The Miyagi Shiryō Net (MSN) is an NGO whose members are professional academics, amateur historians and interested citizens, who work on a volunteer basis to identify, record and preserve the historical heritage of Miyagi Prefecture. MSN was founded in July 2003 in response to the recurring earthquakes and subsequent loss of the historical heritage of Miyagi Prefecture. Major earthquakes occurred again in 2005 and 2008, and culminated the Great East Japan Earthquake of March 2011.

No. & Location of Salvage Operations by Miyagi Shiryō Net as of December 2013

<table>
<thead>
<tr>
<th>City</th>
<th>No. of Salvage Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Senda</td>
<td>11</td>
</tr>
<tr>
<td>Sendai</td>
<td>11</td>
</tr>
<tr>
<td>Murata</td>
<td>5</td>
</tr>
<tr>
<td>Watari</td>
<td>4</td>
</tr>
<tr>
<td>Yamamoto</td>
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</tr>
<tr>
<td>Natori</td>
<td>1</td>
</tr>
<tr>
<td>Ichinoseki</td>
<td>2</td>
</tr>
<tr>
<td>Otsuchi</td>
<td>1</td>
</tr>
<tr>
<td>Ofunato</td>
<td>3</td>
</tr>
<tr>
<td>Rikuzen Takata</td>
<td>1</td>
</tr>
<tr>
<td>Kesen’numa</td>
<td>5</td>
</tr>
<tr>
<td>Minami Sanriku</td>
<td>7</td>
</tr>
<tr>
<td>Kitakami</td>
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</tr>
<tr>
<td>Kahoku</td>
<td>2</td>
</tr>
<tr>
<td>Ogatsu</td>
<td>3</td>
</tr>
<tr>
<td>Monou</td>
<td>3</td>
</tr>
<tr>
<td>Onagawa</td>
<td>7</td>
</tr>
<tr>
<td>Ishinomaki</td>
<td>4</td>
</tr>
<tr>
<td>Shiozaki</td>
<td>3</td>
</tr>
<tr>
<td>Old Ishinomaki</td>
<td>21</td>
</tr>
</tbody>
</table>

Total Salvage Operations: 105

No. of Collections taken into Primary Custody: 88
How salvaging heritage generates powerful psychosocial support: Part 1

• The salvage operations, and the on-going storing and treating of materiels at risk (still continuing 11 years on) can provide vital bridging and linking social capital between heritage owners and a wide variety of people outside the owners’ community.

• Serving as volunteers provides an avenue for a wide variety of people, especially elderly people, to participate in contributing to recovery from the disaster. Continued participation in treating damaged documents provides participants with a place, companionship, and a sense of purpose.
How salvaging heritage generates powerful psychosocial support: Part 2

- It is essential to give feedback on what can be learnt about a family or community’s history from the salvaged documents. This can take the form of cataloguing the collection, providing print-outs of the digital record, public lectures to the community, and publishing.

- Moreover, co-operating with other specialists, e.g., psychologists experienced in support for disaster survivors, can greatly enhance the positive effects of salvage operations for private heritage collections.

Left: books published by members of MSN & Tōhoku Uni.
Right: a public lecture

Photo compliments of TAKAHASHI Yō’ichi
Owners in their own words: Case 1

A: Woman in her 70's

'I realised the meaning of why I was born into this world'

【Conflicting feelings】
I thought that losing everything in the tsunami was just a dream -
I was very happy +
Later on, I longed for the life that I had lost -
Thinking about it all is frustrating and painful +
I have come to see the world in new and positive light +
I was very grateful +

【Having Prof. C help me】
I was very grateful and glad when Prof. C rang me up +
（Ranked as most important）
Prof. C gave me 10 copies of his book, and I gave them all to my relatives. It made me glad to see them all so happy to get the book. +

【Looking to the future】
I am proud of what my family has done +
I gave my grandchildren a copy each +

Printouts of A’s documents
Owners in their own words: Case 2

B: A man in his 60’s
‘The earthquake is one part of our history, so I want to preserve the traces of it’
‘Thanks to the tsunami, this place was really cleaned up’

[Learning from experience]
Passing on experience +
The earthquake −
Mutual aid +

【The meaning of recording history】
History +
A story +
Passing on experience +
(Ranked as most important)

【Recovery】
The past +
The future +

【Ideas associated with the event】
Appreciation +
Disaster −
Tsunami +
Epilogue: B’s warehouse today has become a repository of local memory

The warehouse sitting on a base of wooden piles as it is moved centimetre by centimetre to a new site to save it from demolition in the rezoning of the area after the tsunami.

Photo compliments of SATÔ Daisuke
Summing up: a Psychological Explication of the Two Cases

• Both A and B are elderly people, without unlimited time left them to rebuild their lives anew from scratch. However, by meeting and interacting with MSN, they became able to accept the reality of the disaster and to discover some positive meaning in all the loss and wreckage.

• In psychological terms, the disaster, taken as a whole experience, has enabled them to reconstruct their ego integrity (as defined by Erik Erikson) within the span of their life cycle.

• The key to understanding the benefits of restoring ‘memory’ in any form, is that psychological health (and disorders) and a healthy self-conception are deeply intertwined with memory.
Concluding Remarks Part 1

• Not all ‘heritage’ is world heritage, national heritage, heritage from ‘long ago,’ nor even ‘good heritage.’ But even so, it is still ‘heritage.’

• The dividing line between ‘heritage’ and ‘garbage’ is blurred, ever-changing, and often contested.

• A disaster can tear communities apart and alter familiar landscapes. Saving anything that records the past, the ‘little history’ of a community can provide members with links to loved but lost people and landscapes.

• These links transcend time, both PAST and FUTURE. They can give people driven into a dead-end, a different perspective to see themselves and each other, and provide a starting point for rebuilding lost human bonds and finding a way out of their dead-end.

• Not only disasters, but long-term socio-economic changes such as commercial ‘development’ can change societies and landscapes beyond recognition within a short span of time. Saving local heritage should be done before disaster strikes.
• The majority of materiel rescued by Miyagi Shiryō Net is less than 100 years old. Photos, old home movies, diaries, personal letters, school/class records, ledger books and other records of commercial activity, posters, etc. can all become a window into some aspect of life as it was.

• The work of volunteer groups such as MSN in Japan provide a cogent example of how items recording the history of a community can be transformed from ‘garbage’ into ‘heritage.’ Properly done, this whole process can become a powerful form of psychosocial support FOR ALL INVOLVED, and for the broader community as well.
A first-hand narrative from local government

• Please read the following online article, by MOMMA Takeshi: ‘Preservation of Historical and Cultural Heritage by Local Government within the Area Affected by the Fukushima Nuclear Reactor Accident,’ in J.F. Morris editor History, Heritage, and Resilience: Case Studies in Saving Historical Heritage as Psychosocial Support

https://mgu.repo.nii.ac.jp/  The site is in Japanese, but look for the ‘Language’ button middle left of screen, to change to English, and look in ‘Miscellaneous’ section.

•
Hazard-sensitive city planning in the era of climate change

APRU multi-hazards summer lecture series

Source: NASA earth observatory

Severe Rainfall and Flooding in Japan | July 2 - 9, 2018

Kanako Iuchi
Tohoku University, IRIDeS | July 29, 2022
Changing climate, intensifying impacts

- Climate change is making different impacts on communities
  - Multiple heatwaves exceeding 40 Celsius hit northern hemisphere in June and July 2022
    - In Japan, worst record since 1875; nationwide heat level triggered electric shortage
  - Rising sea levels
    - Between 1993 and 2021, a rise of 15-20 cm in some ocean basin (NOAA, 2022). Across the world, sea levels are generally rising
  - Intensified meteorological disasters
    - Typhoons and intense rainfall are leading rivers to overflow, urban areas to be inundated, and mountainsides to slide

Source: NASA earth observatory

Source: NOAA
Japan is also facing change in climate: e.g., 2018 Western Japan Torrential Rain

- Intense rainfall for 10 consecutive days June 28 – July 8, more than usual recorded monthly average
- Death toll exceeded 200
- Among the worst meteorological disasters of the past 35 years

Original: "Information for flood prevention" on The Ministry of Land, Infrastructure, Transport and Tourism (Japan) (MLIT), Add animation: Peka - MLIT「川の防災情報」 X バンドレーダ雨量分布 中国, as of 2018-07-10
Intensified meteorological damage has focused attention on land use controls for disaster mitigation

- **Rationale:** By restricting the use of hazardous areas, future loss of life and assets can be reduced
- **Methods:** Land use decisions based on hazard map information

Source: Higashi Matsushima City

**Tsunami simulation**

**Hazard mitigation land use**

**Nobiru area zoning plan**
# Background for spatial risk management in Japan

## Acts related to mitigation of water-related disasters

<table>
<thead>
<tr>
<th>Act</th>
<th>Key Points</th>
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<tbody>
<tr>
<td>Disaster Countermeasures Basic Act (1961):</td>
<td>• Basis for current DRM framework</td>
</tr>
<tr>
<td></td>
<td>• Protect citizens and social order</td>
</tr>
<tr>
<td></td>
<td>• Set the stage for disaster management, including its planning system</td>
</tr>
<tr>
<td>Flood Control Act (1949):</td>
<td>• Protect citizens and assets through mitigation efforts against flooding, tsunami and storm surge</td>
</tr>
<tr>
<td></td>
<td>• Give responsibilities to community groups for managing water-disasters</td>
</tr>
<tr>
<td>River Act (1964):</td>
<td>• Comprehensively manage rivers to mitigate flood disasters</td>
</tr>
<tr>
<td></td>
<td>• Identify and match roles and responsibilities of entities</td>
</tr>
</tbody>
</table>

These acts proclaim to protect people and prepare for disasters; including the need to develop, share and use hazard information...
Spatial laws and regulations addressing disaster risk

- **Building Standards Law, Article 39 (1950)**
  - Local governments designate hazardous areas by enforcing ordinances and controlling building construction from disastrous events (e.g., land slides, surges, floods and tsunamis)

- **City Planning Act (1968)**
  - **Article 7** regulates the need (of the local government) to classify land b/w urbanization promotion areas and urbanization control areas to prevent unregulated development
  - States to consider hazards upon defining land development
  - **Article 33** on the development permit criteria allows of exclusion of lands not suitable for development due to hazard risk
Approaches on land use decisions – the norms

- Develop/revise hazard maps: Incorporating knowledge on hazards
- Translating hazard information into local zoning (e.g., classifications by inundation depth)
- Different building criteria by defined zones
  - E.g., enforcing special building codes to certain zones

1. Hazard map development
2. Land use decisions based on hazard info

<table>
<thead>
<tr>
<th>Zone</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>No residential and medical+welfare facilities</td>
</tr>
<tr>
<td>Zone 2</td>
<td>Building construction is restricted, but can be constructed with conditions</td>
</tr>
<tr>
<td>Zone 3</td>
<td>Buildings can be constructed by raising the floor level</td>
</tr>
</tbody>
</table>

Source: Higashi Matsushima City

Figure source: MLIT
With intensified weather, hazard maps are changing

- Hazard maps and risk maps are revised/developed for the worst scenario --> hazardous areas are expanding
- Some high-risk lands are designated hazardous (red zones)

○ Flood hazard map

○ Flood risk map

Source: All figures by MLIT
• **Red zone**: areas designated hazardous under evaluations guided by different Acts (e.g., Flooding, Landslides, mudslides, steep slope collapse)

• Increasingly, red zones are proactively considered upon city/land use planning


Source: City of Sendai
In practice, enforcing land use controls is difficult

- At normal times, local governments are hesitant to restrict the use of valuable land
- Locations designated hazardous have mostly resulted from spot and slope failures

<table>
<thead>
<tr>
<th>Mudslides</th>
<th>Steep slope collapse</th>
<th>Landslides</th>
<th>Hazardous locations for landslide disasters (Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous points (Red zones)</td>
<td>Hazardous points (Red zones)</td>
<td>Hazardous points (Red zones)</td>
<td>Hazardous points (Red zones)</td>
</tr>
<tr>
<td>215,276</td>
<td>156,806</td>
<td>446,607</td>
<td>423,308</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15,934</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>677,817</td>
</tr>
</tbody>
</table>

Data by MLIT, retrieved on July 27 from: http://www.sabo.or.jp/topics/0005-0508/shitei-jyoukyou.htm
Historically, large hazardous areas (including red zones) are designated after significant disasters.

<table>
<thead>
<tr>
<th>Location (City, Prefecture, year)</th>
<th>Triggering Event (Year)</th>
<th>Known area designated hazardous (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nagoya, Aichi Pref. (Adopted 1961)</td>
<td>Isewan Typhoon (1959)</td>
<td>70.6km² (17 areas)</td>
</tr>
<tr>
<td>Kobe, Hyogo Prefecture (Adopted 199?)</td>
<td>Kobe earthquake (1995)</td>
<td>0.0195 km² (1.95 ha)</td>
</tr>
<tr>
<td>Nagaoka, Niigata Prefecture (Adopted 200?)</td>
<td>Chuetsu earthquake (2004)</td>
<td>0.2797 km² (27.97 ha)</td>
</tr>
<tr>
<td>Tohoku (Iwate, Miyagi, Fukushima Prefs.) (Adopted 2013 later revised)</td>
<td>The GEJE (2011)</td>
<td>157.23 km² (as of 2014)</td>
</tr>
</tbody>
</table>

Created: from various MLIT sources
Land designated hazardous is greatly increasing

- After the GEJE Tohoku, land area designated hazardous has increased by 21 times

![Chart showing the increase in hazardous land areas before and after the GEJE Tohoku.](https://www.nikkei.com/article/DGKKZO69032700Q1A210C2CC1000/)

- Similar trends can be seen nationwide with increased meteorological disasters
Emerging issues and responses

- Designated hazardous lands had continued to increase for the past 70 years.
- With intense weather, hazardous areas continue to widen in each location → not all the areas can be restricted.
- Patterns of hazard forces (e.g., rain, typhoons) are increasingly unpredictable.
- Hazard and risk maps prove to be less useful than anticipated.

Some prefectures (e.g., Aichi in 2022) have reverted the restricted area – based on a revised hazard assessment.

Reverting is the opportunities for better use of land; but keep sharing the past information is important → Hazard maps builds on assumptions.
Conclusion

• Efforts to reduce hazard impacts will continue and grow
  – Improved technologies enable better predictions
  – Increase awareness and practice on hazard risk reduction, e.g.,
    designating more hazardous lands

• However, the traditional approach to hazard-sensitive land
  use is at a point of shift in perspective
  – Extreme meteorological impacts of climate change bring
    unpredictable impacts
  – Traditional risk reduction efforts via hazard mapping/land use may
    not meet the speed of climate change

• Good news: We see changes on city/land use planning
  – As a sign of adaptation to the current environment, former land use
    decisions are revisited; reverting the restricted area

Studying better use hazard information and wisely adopting to the
changing environment is important
Questions?
iuchi@tohoku.ac.jp