LRRI 技術情報，Vol.2，No.2，pp.1-88，2024.3

気候変動に対する地盤工学的対応策

安原一哉

（一社）地域国土強靭化研究所　代表理事

概　要

◆目的・主旨

気候変動を含めたサステナビリティに対する地盤工学的対応策の現状を紹介することによって、この方面の地盤工学の関心を高揚させることを目的とする。

◆話題の概要

「気候変動における持続可能性への地盤工学的貢献」

安原一哉

サステナビリティのうち、気候変動に伴う地盤災害（特に、複合災害）に焦点を当て、現状の分析と今後の対応策を展望した。加えて、IPCC 等の国際機関に対する貢献策も併せて提案した。

「丸太を用いた液状化対策による気候変動緩和貢献の事例紹介」

村田拓海

気候変動緩和策としての地盤災害対策への木材利用の可能性に焦点を当て、大規模分譲住宅地に丸太を用いた液状化対策工法を適用した事例と、その工事における炭素貯蔵効果を紹介した。

「産官学連携による地方都市における木材利用促進と社会貢献」

吉田雅穂

木材資源の豊富な地方都市の福井県における、産業振興、地域活性化、国土強靭化、気候変動緩和への貢献を目的として、産学官が連携した木材利用研究会の活動を照会した。

「気候変動における持続可能性に関する **LRRI** の活動」

安原一哉

地域国土の強靭化の課題のうち、気候変動に伴う地盤災害に焦点を当て、LRRI における過去 3 年間の取り組みを報告し、併せて、LRRI 会員の所有する関連の技術例を紹介した。

◆知見・結論の要点

SDGs のなかで取り上げられている“気候変動”に対する対応策（緩和策、適応策、緩和策と適応策の融合）の事例を紹介し、地盤技術もこのことに貢献することができることを示した。

◆知見の意義

地盤工学が地域社会のサステナビリティにも貢献できる分野であることで認知を広げることができる。併せて、LRRI の認知の拡大にも繋げることができる。

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第 I 編

1. CREST 2023 の概要

資料 (Ref.)：1

第2回 環境に配慮した持続可能な建設技術に関する国際会議

2nd International Conference on Construction Resources for Environmentally Sustainable Technologies

CREST 2023 | 2023年11月20-22日
福岡国際会議場

主催
九州大学

共催
英国ケンブリッジ大学
公益社団法人土木学会
公益社団法人地盤工学会
公益社団法人 日本地すべり学会
国際地盤工学会 技術委員会 No. 307 (TC307)
国際地盤工学会 アジア地域技術委員会 (AsRTC 1)
国際地盤工学会 アジア地域技術委員会 (AsRTC 3)
国際圧入学会 (IPA)
一般社団法人GLOSS研究会

後援
国土交通省九州地方整備局
福岡県
福岡市
公益社団法人地盤工学会九州支部
公益財団法人日本材料学会
一般社団法人日本建設業連合会
一般社団法人建設コンサルタンツ協会
一般社団法人全国地質調査業協会連合会
NPO法人廃棄物地盤工学研究会
特定非営利活動法人応用斜面工学研究会
一般社団法人地域国土強靭化研究所

SDGsへの取り組み

CREST 2023

概要

CREST 2023(第2回環境に配慮した持続可能な建設技術に関する国際会議)は、自然災害や人為的活動に伴う災害について情報発信や意見交換を行い、ジオエンジニアリングの観点から、持続可能でレジリエントな社会を構築するために、代替資源や革新技術、ソフトタイプの災害軽減策を用いた解決策を提供することを目標としています。

第1回の国際シンポジウム(CREST 2020)は、新型コロナウイルスの感染拡大による困難の最中、数回の延期を経て2021年3月にオンライン方式で開催致しました。お陰様でCREST 2020は、産・官・学の皆様から圧倒的な支持と激励を受けて成功裏に開催することができました。これを機に国際会議として更に発展させるべく引き続きCREST 2023を開催することにいたしました。

新たな災害リスクを防止し、既存の災害リスクを軽減するための行動の優先順位を設定した「仙台防災枠組2015-2030」の決議にしたがい、CREST 2023のテーマは地盤工学のみならず幅広い学際的な分野をカバーしています。その中で特に重要なのは、効果的な災害対応のための予防措置を強化し、復旧・再建段階における「より良い復興体制の構築」を目指すことです。これを災害リスク軽減に組み込むことで、国や地方公共団体、地域のコミュニティは将来の災害に対して強靭な回復力を発揮することに繋がります。

また、現在、気候変動による自然災害の増加に直面し、世界各国は二酸化炭素排出量を削減するために、より厳しい環境政策を採用しています。このような社会背景のもと、持続可能で災害に強い社会の実現に向けて貢献することは、資源集約型の建設に携わる研究者、技術者、政策立案者の責務であると考えられます。

急速に変化する世界において、これらを達成する方法として、スマートで革新的なデジタル技術(たとえばAI、BIM、CIM、DX、IoTなど)とともに、資源とその副産物を利用することが挙げられます。革新的な資源の最適化は、建設事業における環境負荷の低減に役立ち、デジタル技術は、設計・施工段階での非効率性を排除するだけでなく、耐用期間に亘ってシステム性能の継続的なモニタリングや、災害時の被害リスクの低減にも役立ちます。

達成目標

本会議は、世界各国の研究者、技術者、政策立案者が一堂に会し、地盤工学のみならず広範な学際的テーマについて議論をすることを目的としています。

CREST 2023では、持続可能な開発目標(SDGs) No.9、No.11、No.13、No.17に関して、気候変動への適応と災害への耐性に貢献することを目的として、インフラの政策立案、設計、施工、維持管理における新しいアイデアとイノベーションを促進します。

論文募集

CREST 2023実行委員会は、本会議のテーマに基づき、アブストラクトを募集しています。アブストラクトは、docxおよびpdf形式(400単語以内)で、オンライン投稿システムで提出してください。すべてのアブストラクトは、技術委員会によって査読され、採用された場合には、エクステンデッドアブストラクト(2ページまたは4ページ)とフルペーパー(8ページまたは10ページ)を提出していただきます。エクステンデッドアブストラクトはプロシーディングスに掲載され、フルペーパーはSpringer Nature社によるシリーズ出版物としてポストカンファレンスプロシーディングスに掲載される予定です。論文の投稿者は、フルペーパーが受理された後に会議に登録することができます。アブストラクト、エクステンデッドアブストラクト、フルペーパーの投稿要領とテンプレートは、本会議のウェブサイトからダウンロードしてください。また、若手研究者を対象に、優秀な論文や発表に対して表彰致します。また、推薦論文は、地盤工学をはじめ著名な学術雑誌の特集号に掲載される予定です。

テーマ

テーマ1:地盤工学に関連した自然災害とレジリエンシー

① 気候変動に起因した自然災害
② 気候変動に起因しない自然災害
③ 人為的活動に関連する災害
④ 災害リスクの評価とモデル化の経済的側面

テーマ2:地盤工学の観点から気候変動への適応策と技術革新

① 低炭素に向けた革新的技術
② 持続可能な設計・施工のための革新的な事例研究
③ 社会、経済及び環境に配慮した持続可能な施工技術
④ 地質学・水文学的な観点

テーマ3:異分野連携による地盤工学におけるサステナベーション

① 情報(AI、IoT、VRなど)に基づいた自然災害軽減の方策
② DXやi-Constructionの応用
③ 災害の物理的・数値的なモデリングと災害軽減技術
④ スマートなエネルギー採取技術

テーマ4:地盤工学におけるリサイクル材・廃棄物の利用

① 低コスト・低炭素の建設技術
② 地盤構造物におけるリサイクル材料(代替地盤材料)の利活用
③ リサイクル材の力学的な性質及び構成則
④ 災害廃棄物の管理と再利用

テーマ5:レジリエントな社会の実現のための施策

① 地盤災害と環境
② ソフトタイプの災害軽減策によるコミュニティアウトリーチ
③ 持続可能な開発目標のための教育
④ Society 5.0の目標達成のための施策

スケジュール

アブストラクト投稿開始	2022年01月15日
アブストラクト提出期限	**2022年04月30日**
アブストラクト受理通知	2022年05月31日
エクステンデッドアブストラクトとフルペーパー投稿開始	2022年05月31日
エクステンデッドアブストラクトとフルペーパー提出期限	2022年09月30日
フルペーパー受理通知	2022年12月31日
フルペーパー最終提出期限	2023年01月31日
参加者登録開始	2023年02月01日

CREST 2023

参加費(円)

参加者カテゴリ	早期割引 2023年05月31日以前	一般 2023年05月31日以後
一般	55,000 円	65,000 円
学生	35,000 円	45,000 円
一日のみの参加	20,000 円	30,000 円
同伴者	20,000 円	30,000 円
論文追加投稿料	15,000 円	20,000 円
バンケット	10,000 円	10,000 円

補足説明:

1. 参加費には、現場見学またはワークショップ、ウェルカムレセプション、プロシーディング、大会期間中のコーヒー、ランチ代が含まれます。
2. 一般参加者および学生の参加費には、説明1に記載されているすべてのサービスおよびフルペーパーの掲載料(Springer Nature社によるシリーズ出版物)が含まれています。

実行委員会 委員長

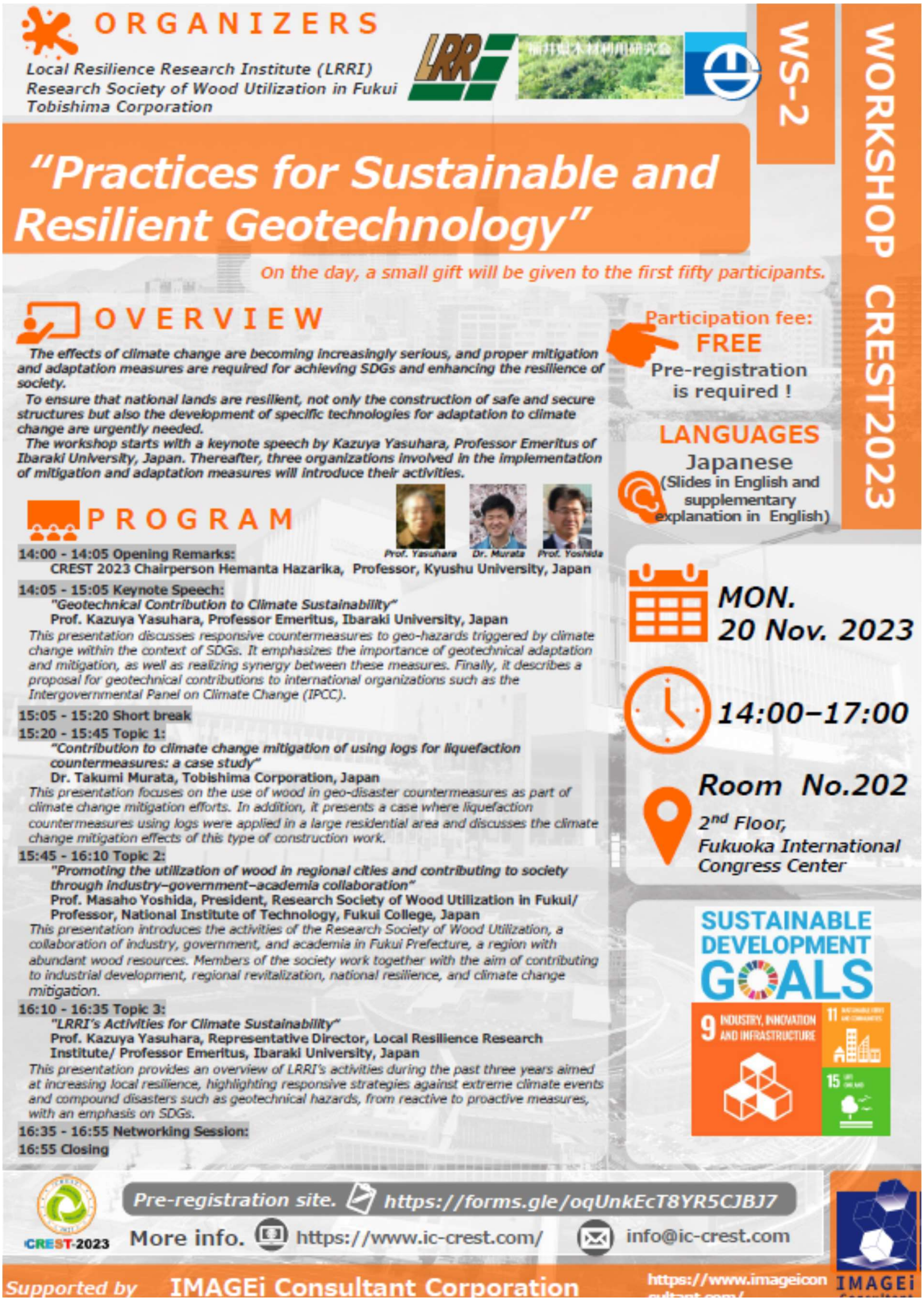
九州大学大学院 工学研究院 社会基盤部門 教授
ハザリカ ヘマンタ

問い合わせ先

CREST 2023 実行委員会
〒819-0395 福岡県福岡市西区元岡744 W2-1124
九州大学 グローバル地盤災害環境研究グループ
E-mail: info@ic-crest.com | Website: www.ic-crest.com

**詳しい情報は、
バーコードをスキャンしてください。**

2. CREST 2023 WORKSHP 2 の概要



主　催
(一社)地域国土強靭化研究所(LRRI)
福井県木材利用研究会
飛島建設(株)

WS-2

WORKSHOP CREST2023

持続可能で強靭な地盤技術の現状

当日，先着50名様に粗品をプレゼントいたします．

概　要

気候変動の影響はますます深刻になってきており、SDGsの達成のためにも、その緩和策と適応策が必要になっています。同時に、強靭な国土つくりも必要です。したがって、強靭な国土をつくるためには、安全で安心な構造物を構築するだけではなく、気候変動対策も実施できるような具体的な技術開発が必要になってきています。

本ワークショップは、最初に、安原茨城大学名誉教授の基調講演を行い、次に、3機関より、これらに対する具体的な活動を紹介します。

参加費:無料
事前登録が必要です!

使用言語
日本語
(英語での補足説明あり，スライドは英語です)

プログラム


Prof. Yasuhara　Dr. Murata　Prof. Yoshida

14:00 - 14:05 開会挨拶:
CREST 2023実行委員長 ハザリカ　ヘマンタ，九州大学教授

14:05 - 15:05 基調講演:
「気候変動における持続可能性への地盤工学的貢献」
安原一哉，茨城大学名誉教授
サステナビリティーのうち，気候変動に伴う地盤災害（特に，複合災害）に焦点を当て，現状の分析と今後の対応策を提案する．加えて，IPCC 等の国際機関に対する貢献方策も併せて提案する．

15:05 - 15:20 休　憩:

15:20 - 15:45 話題提供 1:
「丸太を用いた液状化対策による気候変動緩和貢献の事例紹介」
村田拓海，飛島建設(株)技術研究所研究員
気候変動緩和策としての地盤災害対策への木材利用の可能性に焦点を当て，大規模分譲住宅地に丸太を用いた液状化対策工法を適用した事例と，その工事における炭素貯蔵効果を紹介する．

15:45 - 16:10 話題提供 2:
「産官学連携による地方都市における木材利用促進と社会貢献」
吉田雅穂，福井県木材利用研究会会長/福井工業高等専門学校教授
木材資源の豊富な地方都市の福井県における，産業振興，地域活性化，国土強靭化，気候変動緩和への貢献を目的として，産官学が連携した木材利用研究会の活動を紹介する．

16:10 - 16:35 話題提供 3:
「気候変動における持続可能性に関するLRRIの活動」
安原一哉，(一社)地域国土強靭化研究所(LRRI)代表理事/茨城大学名誉教授
地域国土の強靭化の課題のうち，気候変動に伴う地盤災害に焦点を当て，LRRI における過去3年間の取り組みを報告し，併せて，LRRI 会員の所有する関連の技術例を紹介する．

16:35 - 16:55 名刺交換会:

16:55 閉　会:

2023年
11月20日(月)

14:00−17:00

福岡国際会議場
2階
202室

SUSTAINABLE DEVELOPMENT GOALS
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

CREST-2023
参加事前登録サイト https://forms.gle/oqUnkEcT8YR5CJBJ7
詳細情報 https://www.ic-crest.com/　info@ic-crest.com

後　援　株式会社 IMAGEi Consultant　https://www.imageiconsultant.com/
IMAGEi Consultant

WORKSHOP 2 in CREST 2023

講師 ＆ 司会者プロフィール

【講師】安原 一哉　（一社）地域国土強靭化研究所(LRRI) 代表理事，茨城大学 名誉教授

・1968 年九州大学助手，1971 年西日本工業大学講師，助教授，教授。1990 年茨城大学教授，2010 年茨城大学名誉教授，併せて，現在，同大学地球地域環境創成機構（GLEC）特命研究員，EPS 開発機構会長，（一財）茨城県建設管理センター評議員，水戸地方裁判所専門委員，（一社）茨城県建設コンサルタンツ協会技術顧問，地水開発㈱顧問他。

・2010 年-2014 年 IPCC AR5 Review Editor，2019 年から日越大学（VJU，Hanoi）で，Climate Change Risk Management を講義している。

・専門は，軟弱地盤工学，地盤改良・地盤補強，気候変動対応地盤工学，工学博士。

【講師】村田拓海，飛島建設(株)，副主任

・2014～2022 年飛島建設株式会社技術研究所，現在は飛島建設株式会社土木本部グリーンインフラ部，2023 年土木学会木材工学委員会地中使用木材の耐久性と耐震性研究小委員会委員

・専門は，地盤工学，博士（工学）

【講師】 吉田雅穂，福井県木材利用研究会会長，福井工業高等専門学校教授

・1988 年福井工業高等専門学校助手，1994 年金沢大学工学部土木建設工学科研究員，1998 年福井工業高等専門学校講師，2001 年福井工業高等専門学校助教授，2005 年米国カリフォルニア大学サンディエゴ校研究員，2007 年早稲田大学理工学術院総合研究所客員研究員，2011 年福井工業高等専門学校教授，2021 年国立高等専門学校機構研究推進・産学連携本部本部員,併せて，現在，福井県木材利用研究会会長，（公社）土木学会木材工学委員会委員長，（特非）国際地盤災害軽減機構（ICGdR）副会長他

・専門は，地震地盤工学，博士（工学）

【司会者】沼田淳紀，技術士事務所　ソイルウッド　代表

・1983～2023 年飛島建設株式会社，2006～2014 年早稲田大学客員研究員，2007～2008 年東京大学生産技術研究所研究員，2017 年より高知大学客員教授，2023 年よりソイルウッド代表

・現在，土木学会木材工学委員会幹事，日本 CLT 協会 CLT 土木開発･利用委員会統括主査，日本工学会フェロー

・専門は，地盤工学，木材工学，博士（工学），技術士（建設部門），地盤品質判定士

第Ⅱ編

1. 「気候変動における持続可能性への地盤工学的貢献」　安原一哉

Geotechnical Contribution to Climate Sustainability

Kazuya Yasuhara,
Professor Emeritus, Ibaraki University, Japan
(Representative Director of LRRI, Japan)
Workshop 2 in CREST 2023

(https://www.glec.ibaraki.ac.jp/)

(https://lrri.or.jp/)

CREST 2023

Keynote Speech Entitled

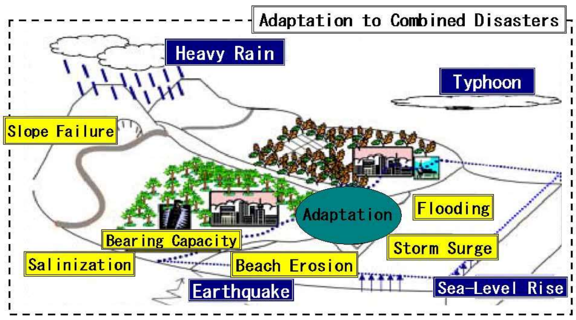
"Technical Practices for Sustainable and Resilient Geotechnical Engineering"

- November 20, 2023

- Fukuoka International Congress Center, Fukuoka, Japan

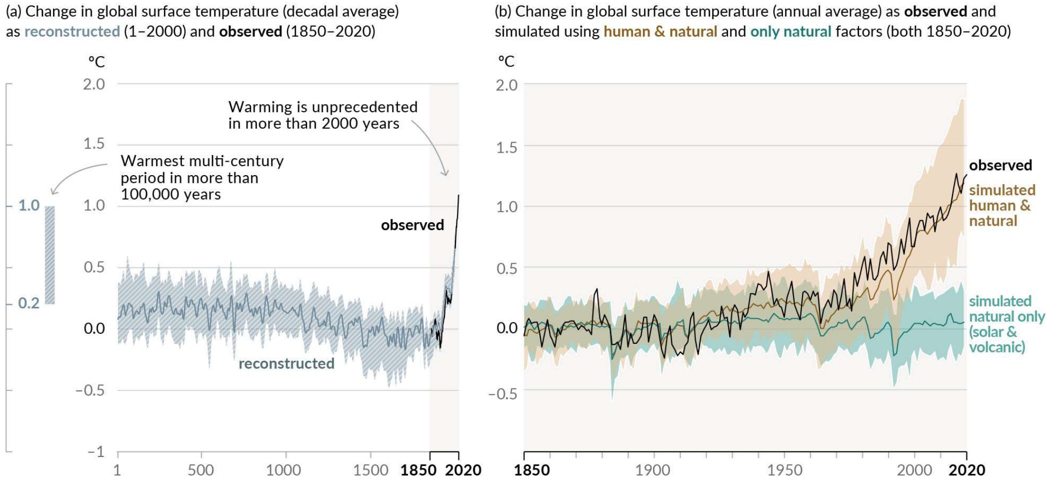
Lecture Content

- ◆ **Background situations**
- ◆ **Compound Event Importance**
- ◆ **Adaptation Strategies for Climate change-induced Disasters**
- ◆ **Increasing Resilience against Climate change-induced Disasters**
- ◆ **Challenges for Increasing Geotechnical Engineering's Role in IPCC**



Background Situations

IPCC AR6:Change in Global Surface Temperature Relative to 1850 - 1900

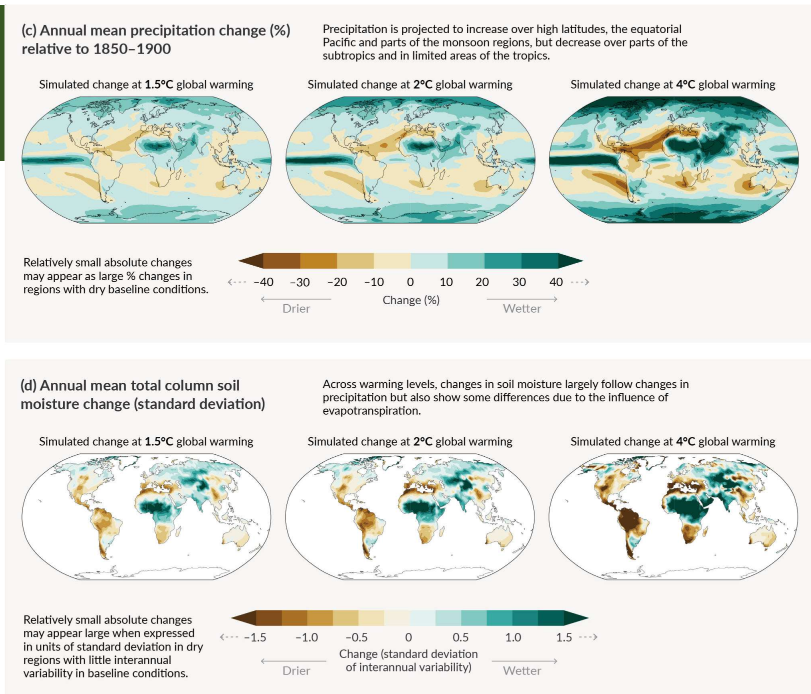


It is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred.

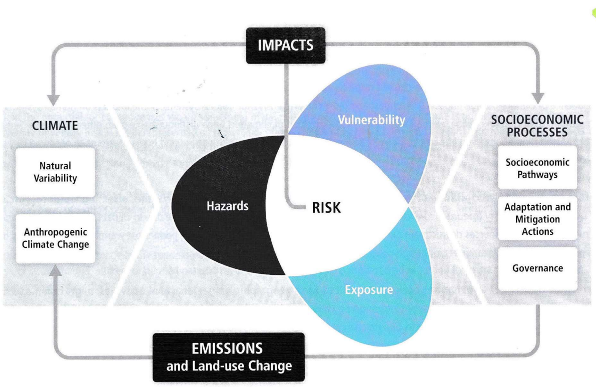
人間活動が気候システムの温暖化および広範で急速な気候変化をもたらしてきたことは疑う余地がない。

IPCC AR6: Precipitation & Soil Moisture Content

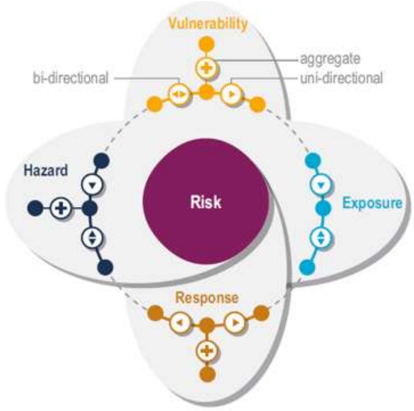
- Many changes in the climate system become larger in direct relation to increasing global warming. They include increases in the frequency and intensity of hot extremes, marine heatwaves, and heavy precipitation, agricultural and ecological droughts in some regions, proportion of intense tropical cyclones as well as reductions in Arctic sea ice, snow cover and permafrost.
- 熱波、豪雨、干ばつ、強い台風、北極海氷・積雪・永久凍土などの損失といった気候システムの変化の多くは温暖化の進行とともに大きくなる。



Definition of Risk in IPCC AR5 and AR6



AR5 2014
（第５次報告書）



AR6 2021
（第6次報告書）

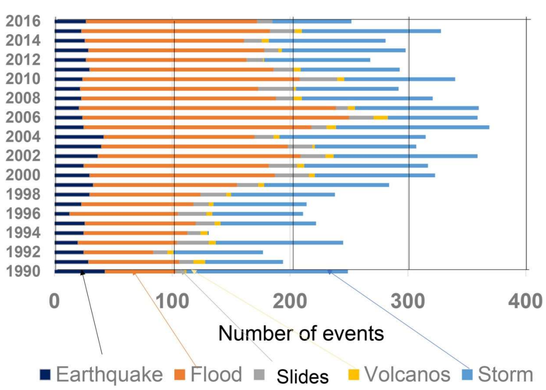
Risk in AR6 is also a function of response in addition to hazard, exposure and vulnerability in AR5. This means that mal-adaptation may increase risk.

Economic Losses, Poverty and Disasters

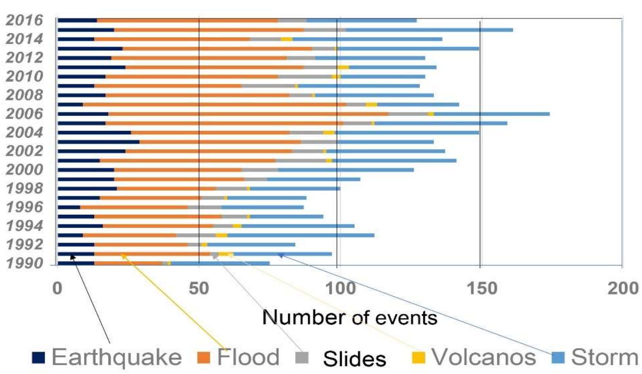
1998-2017
UNISDR

UNISDR: United Nations International Strategy for Disaster Reduction (before 2019)
UNDRR: United Nations Office for Disaster Risk Reduction (after 2019)

Recent natural disasters: Number of occurrences of events



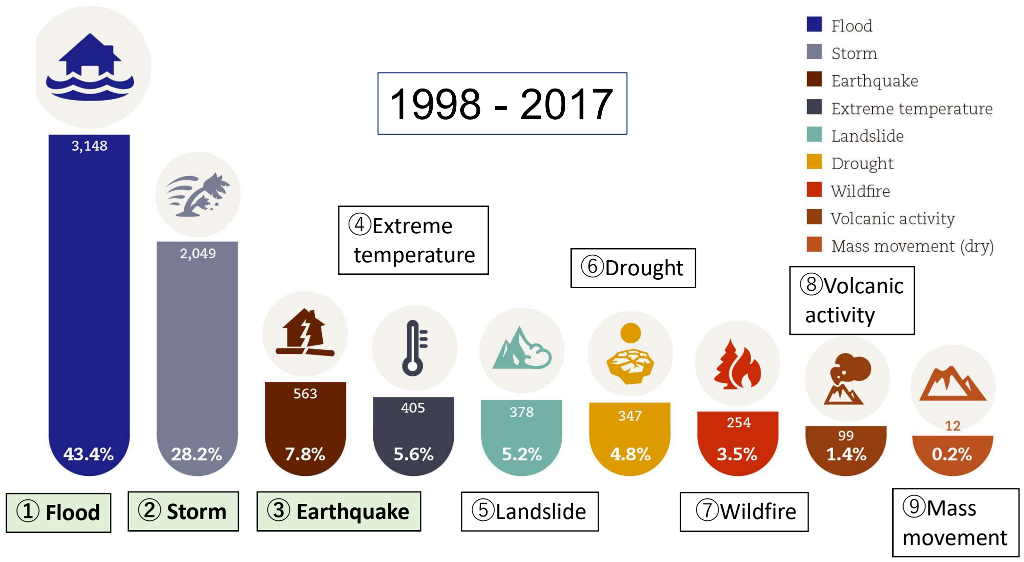
(a) Around the world



(b) In Asia

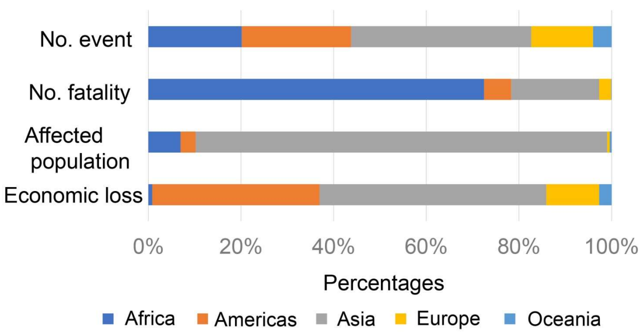
世界，アジアともに水害，暴風，地震が中心

Numbers of Disasters per Type

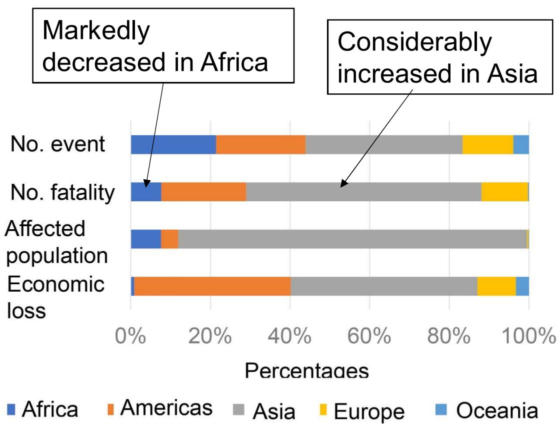


世界中では，災害発生数は，水害が50%弱を占める

Change of Disaster Characteristics



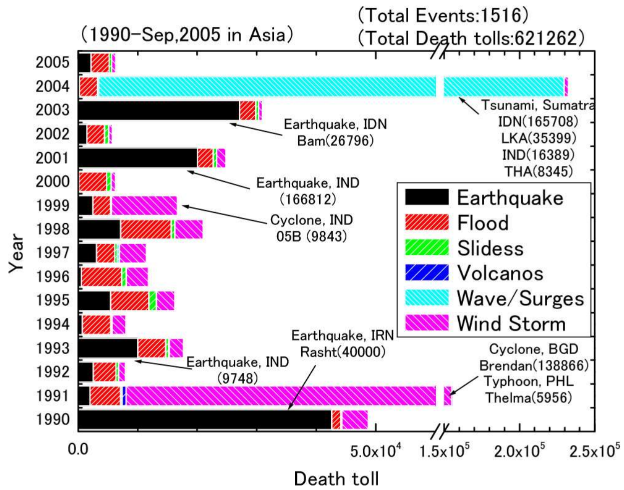
(In the last 27 years 1990 – 2016)



(In the last 15 years 2002 – 2016)

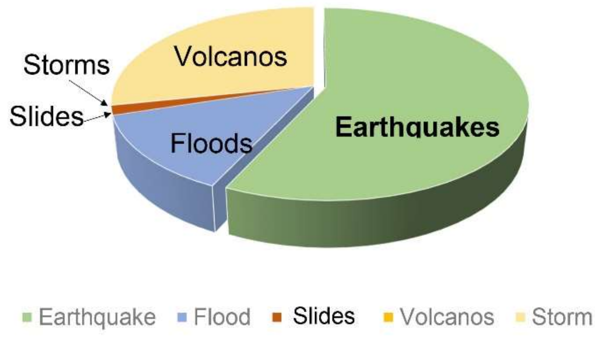
Asia has become the most vulnerable region to natural disasters.
（アジアが最も災害脆弱性が高い！）

Percentages by death



1990--2005 (15 years)

(adopted from Kokusho, T. (2005))



1990--2015 (25 years)

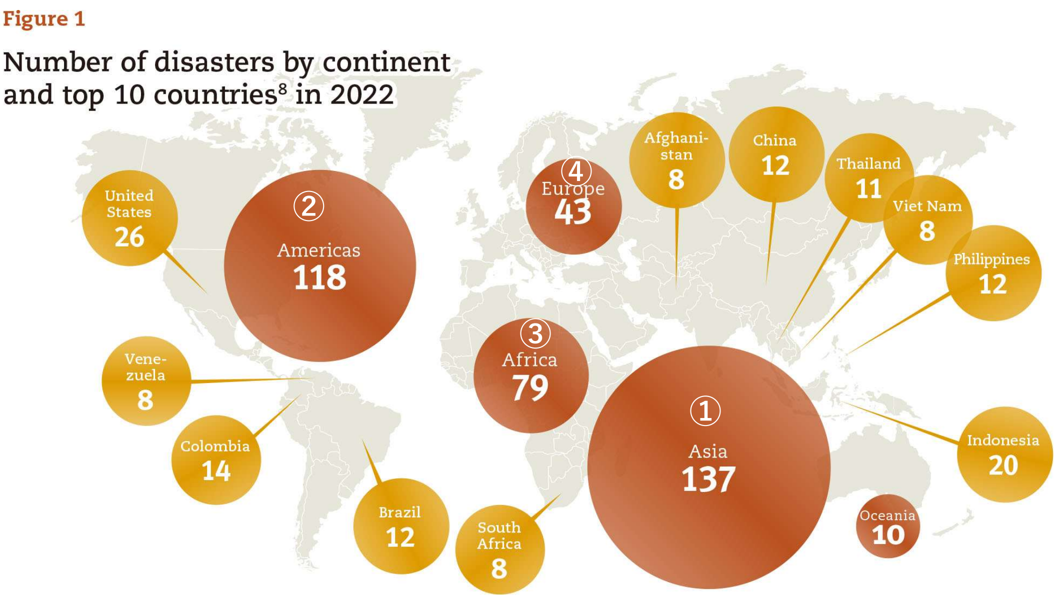
(Present study)

Statistical Data for Disasters from EM-DAT

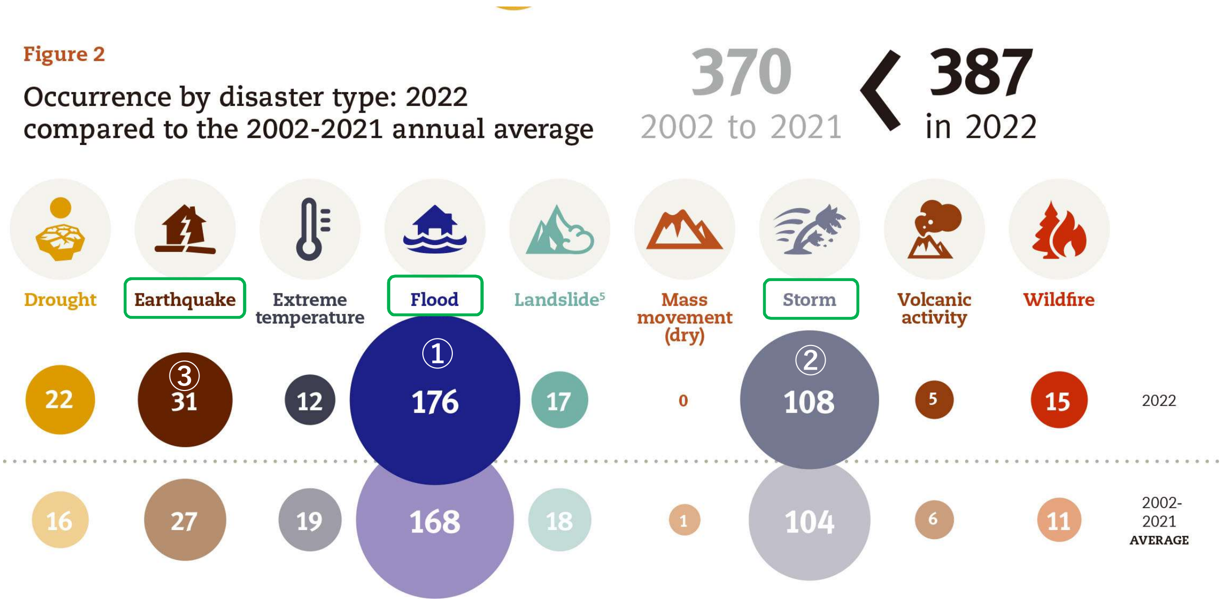
UCLouvain Centre for Research on the Epidemiology of Disasters CRED USAID FROM THE AMERICAN PEOPLE

The **Emergency Events Database (EM-DAT)** has been maintained by the Centre for Research on the Epidemiology of Disasters (CRED) since 1988. The primary objective of EM-DAT is to provide information to support humanitarian action at the national and international level, enabling rational decision-making in disaster preparedness. The database offers objective, evidence-based information that can be used to assess the vulnerability of communities to disasters, thus assisting policymakers in setting priorities.

Number of Disasters by Continent



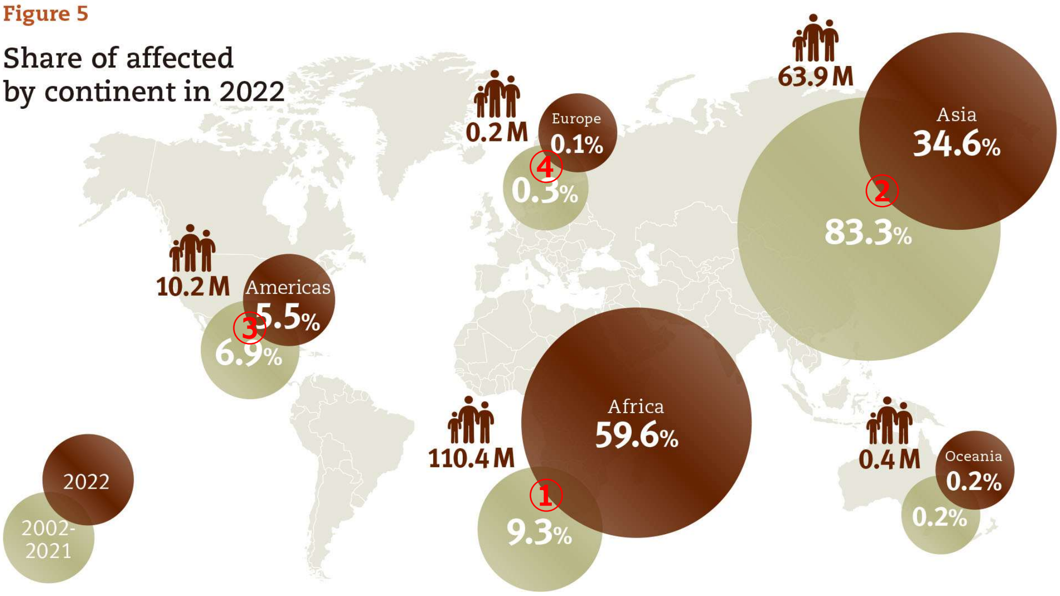
Occurrence by Disaster Type



Human Impact: Total Affected

Figure 5

Share of affected by continent in 2022



Number of Affected by Disaster Type

198.9 2002 to 2021 › 185 in 2022

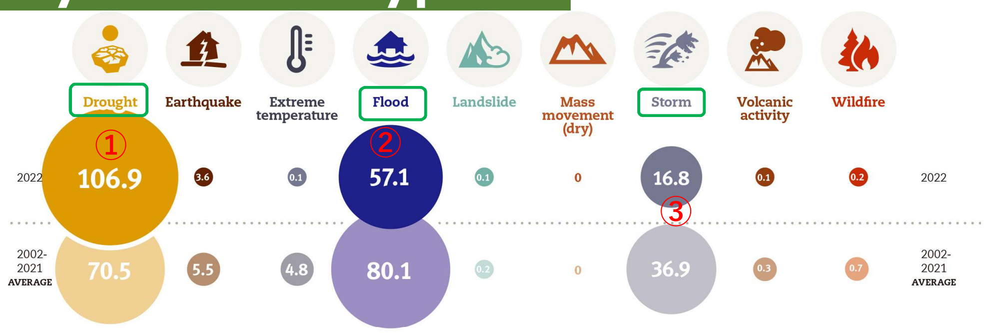


Table 2

Top 10 total affected – 2022

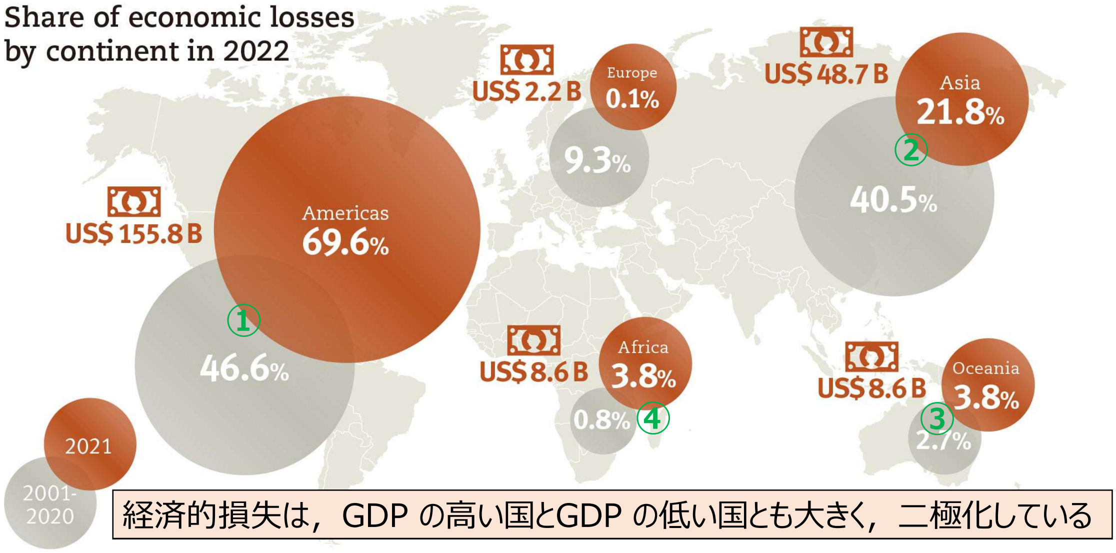
Pakistan	Flood	33.0 million	Bangladesh	Flood	7.2 million
Congo (Democratic Rep.)	Drought	26.0 million	China	Drought	6.1 million
Ethiopia	Drought	24.1 million	Niger	Drought	4.4 million
Nigeria	Drought	19.1 million	Burkina Faso	Drought	3.5 million
Sudan	Drought	11.8 million	Philippines	Storm 'Nalgae'	3.3 million

11 Sum of people injured, homeless, and otherwise affected

Economic Losses by Continent

Figure 7

Share of economic losses by continent in 2022



経済的損失は，GDP の高い国とGDP の低い国とも大きく，二極化している

Economic Losses by Disaster Type

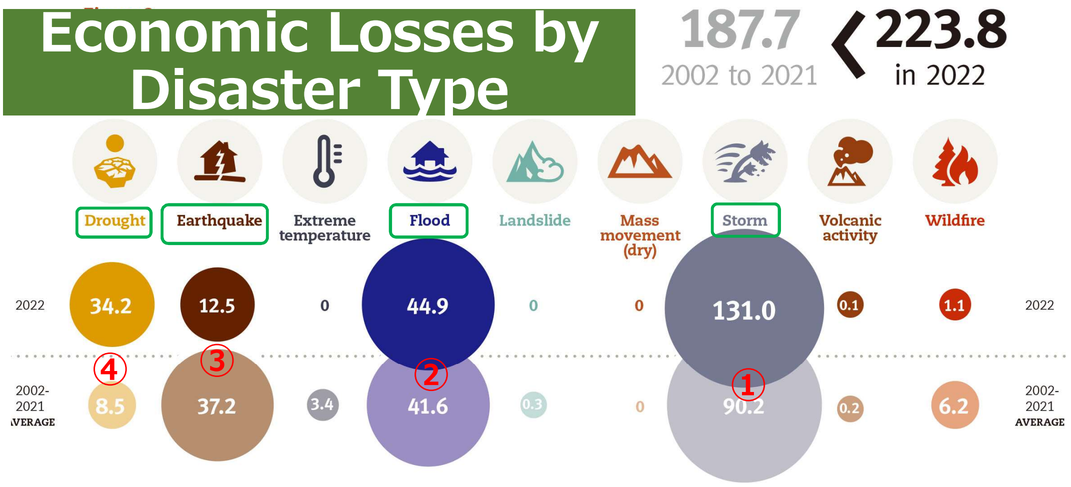
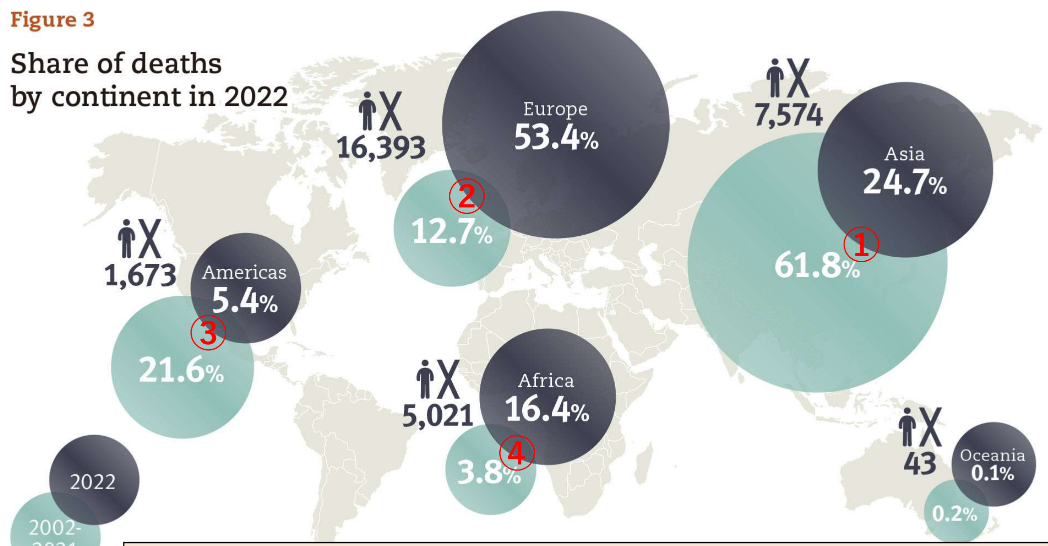


Table 3

Top 10 economic losses - 2022

USA	Hurricane 'Ian'	100.0 billion	Australia	Flood	6.6 billion
USA	Drought	22.0 billion	China	Flood	5.0 billion
Pakistan	Flood	15.0 billion	Nigeria	Flood	4.2 billion
Japan	Earthquake	8.8 billion	India	Flood	4.2 billion
China	Drought	7.6 billion	Brazil	Drought	4.0 billion

Human Impact: Total Deaths by Continent



死者数も，GDP の高い国とGDP の低い国とも大きく，二極化している

Number of Deaths by Disaster Type

60,955 2002 to 2021 > **30,704** in 2022

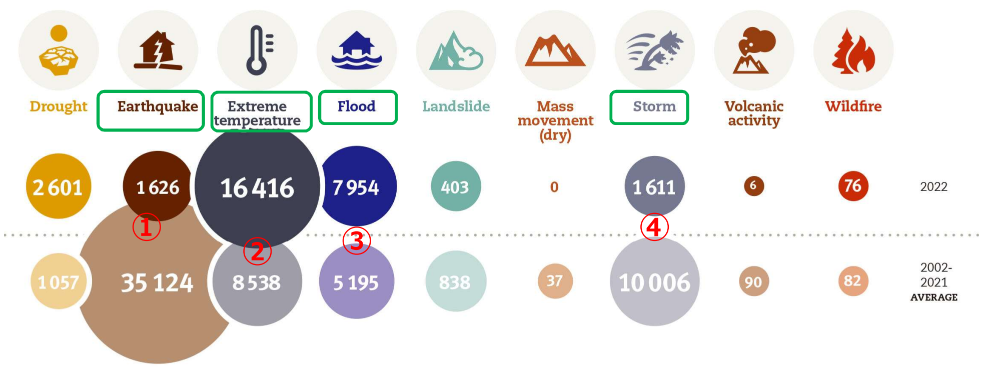
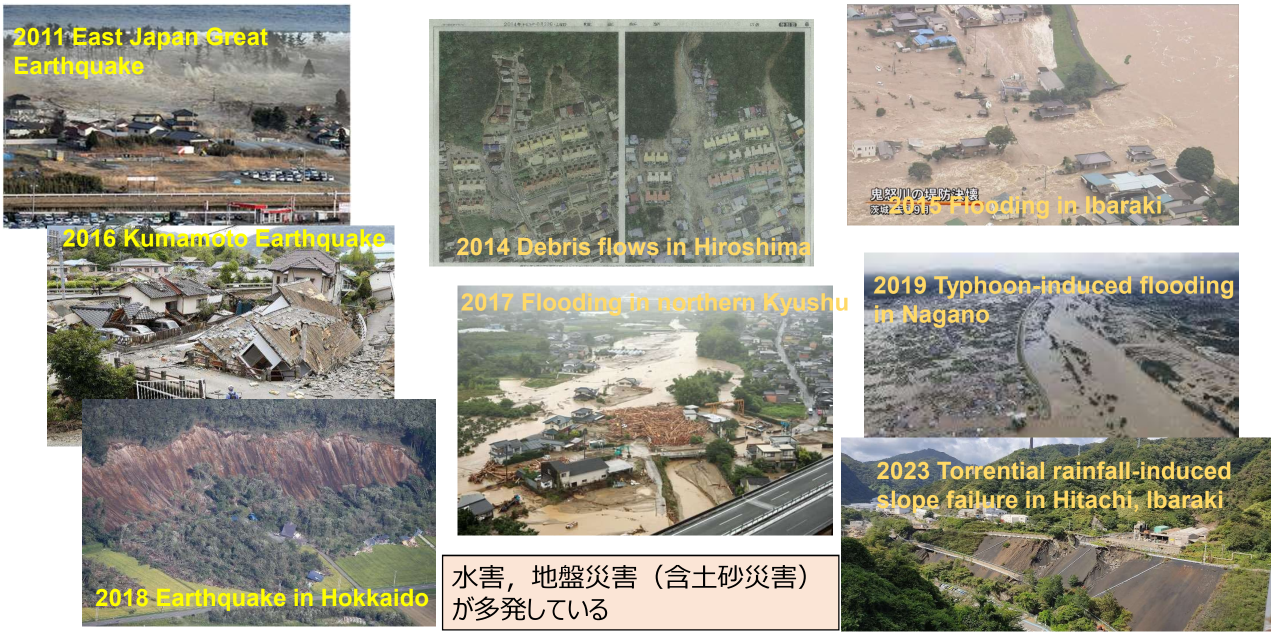


Table 1

Top 10 mortality – 2022

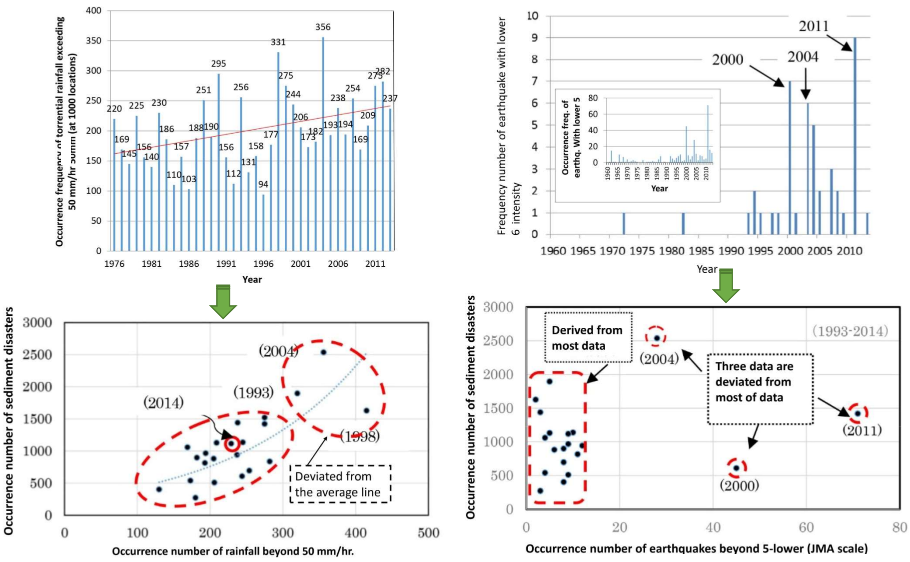
Europe[10]	Heat Wave	16,305	Nigeria	Flood	603
Uganda	Drought	2,465	South Africa	Flood	544
India	Flood	2,035	Philippines	Tropical Storm 'Megi'	346
Pakistan	Flood	1,739	Indonesia	Earthquake	334
Afghanistan	Earthquake	1,036	Brazil	Flood	272

Japanese Situation



水害，地盤災害（含土砂災害）が多発している

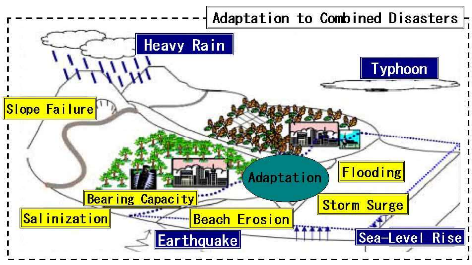
Sediment Disasters Caused by Intense Rainfall and Strong Earthquakes



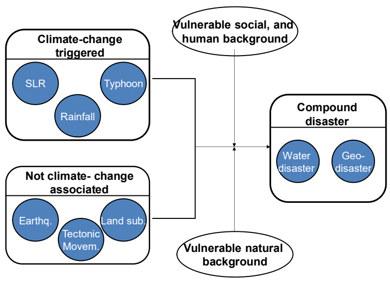
Sediment disasters（土砂災害）are related more closely to torrential rainfall than to strong earthquakes.

Compound Disaster Importance

What are compound disasters（複合災害）？



(a) Disasters caused by overlapping of multiple phenomena

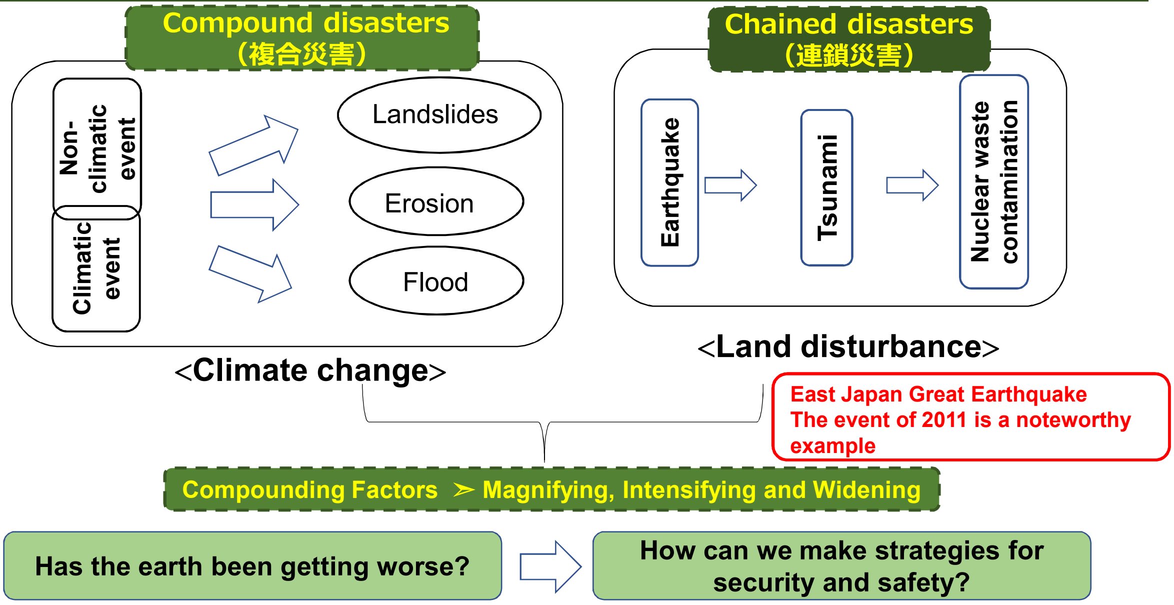


(b) Events and background for increasing compound disasters

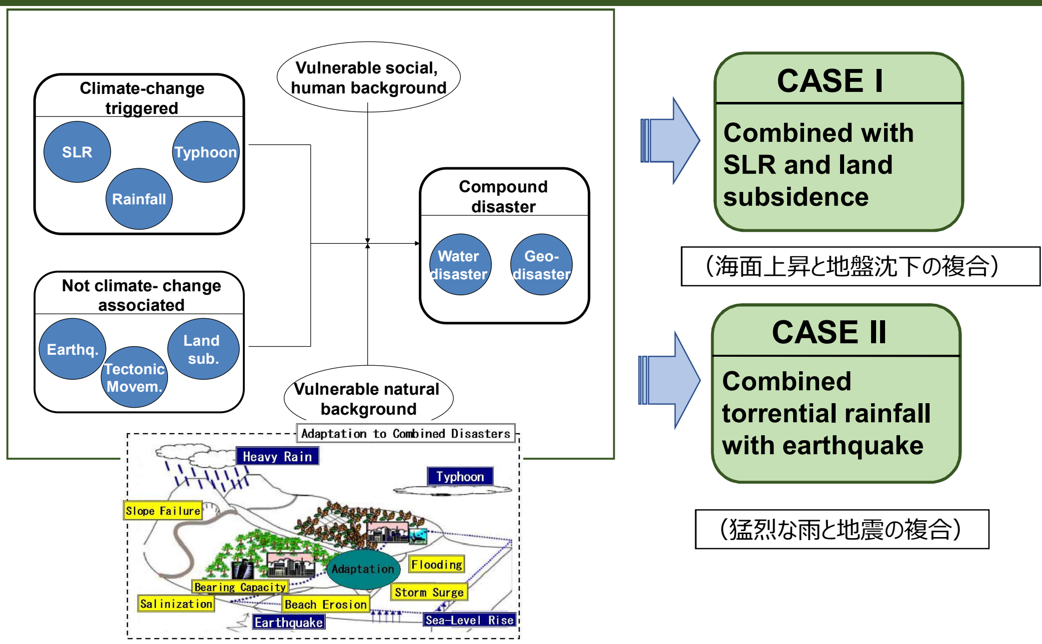
- Overlapping of multiple phenomena triggered by global warming
- Overlapping climate change-associated and non-associated phenomena
  ＋
- Overlapping vulnerable social and natural environments and aged infrastructure

→ **Extreme events**

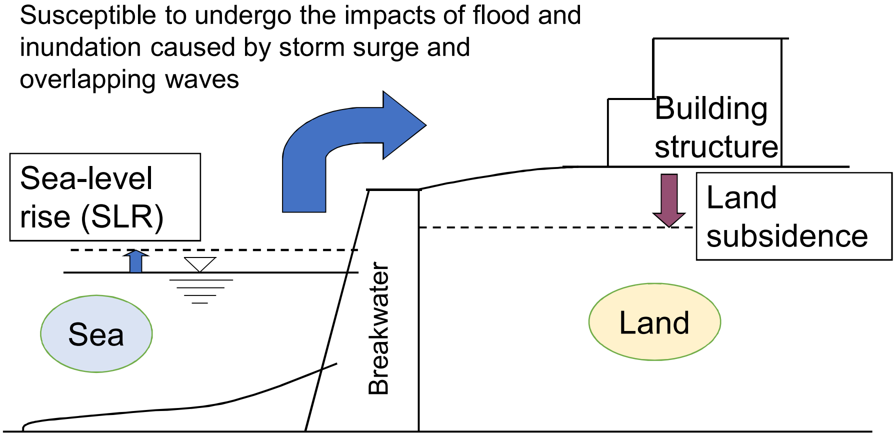
Compound Disasters and Chained Disasters（複合災害と連鎖災害）



Two Examples of Compound Disasters（複合災害の事例）



CASE I: Combined with SLR and land subsidence

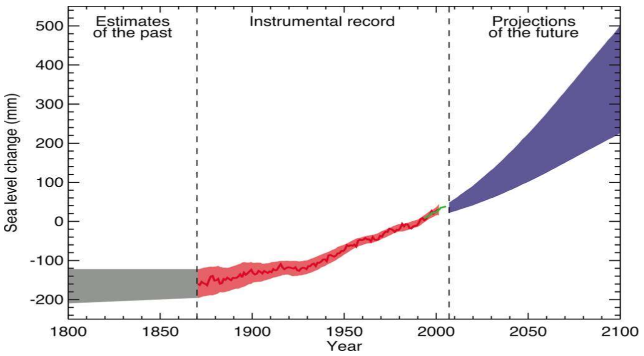


- There are many vulnerable low-lying coastal areas, such as
  - Mega deltas (Niles, Ganges, Mekong)
  - Important coasts (Venice, New Orleans)

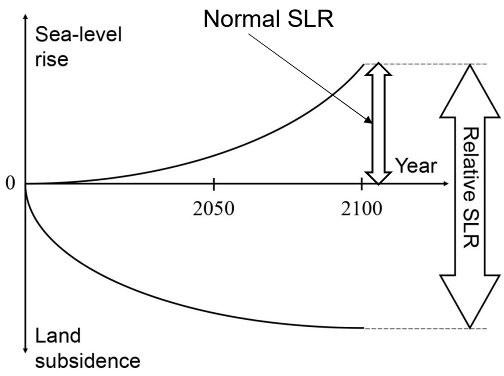
Objective Areas among Vulnerable Coastal Deltas (Chao Phraya Delta in Thailand, チャオプラヤデルタ，タイ国)

Relative vulnerability of coastal deltas (IPCC WGII, 2007)

Definition of Relative Sea-Level Rise (SLR)

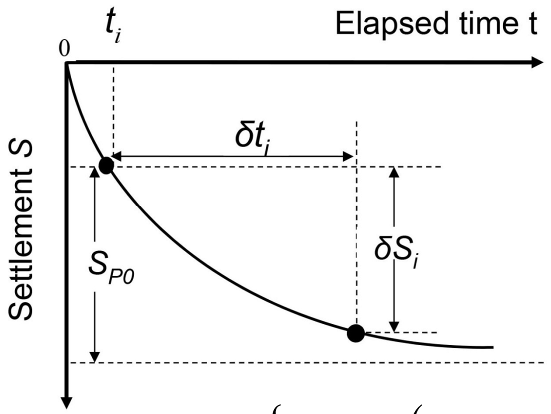


(a) Typical variation of SLR with elapsed time in 2100 (IPCC, 2007)



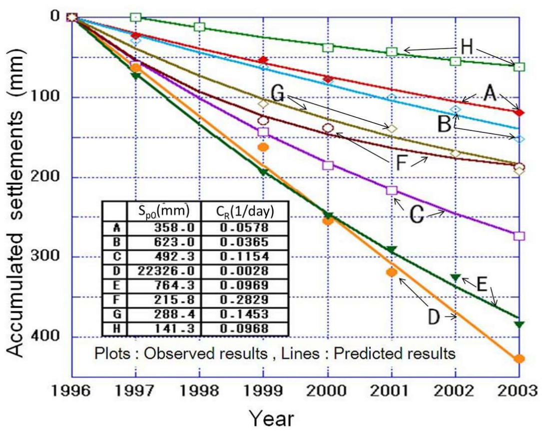
(b) Definition of relative sea-level rise (SLR)

Observational Prediction Procedures for Land Subsidence (Murakami et al., 2004))



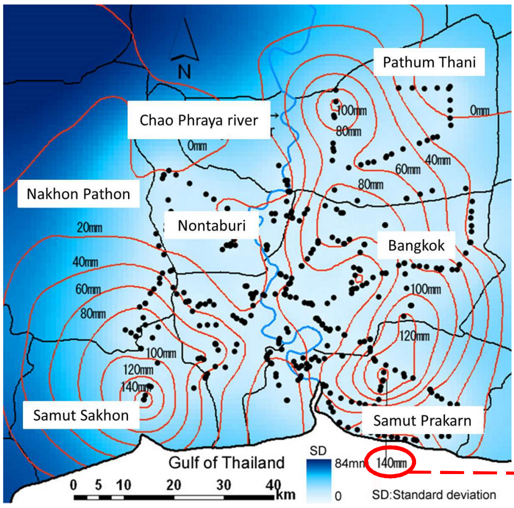
$$\delta S_i = S_{P0}\{1 - \exp(-C_R \delta t_i)\}$$

$$S_{p0} = S_f \frac{8}{\pi^2} \exp\left(-\frac{T_{v0}}{4}\right) \qquad C_R = \frac{\pi^2}{4} \frac{c_v}{H_d^2}$$

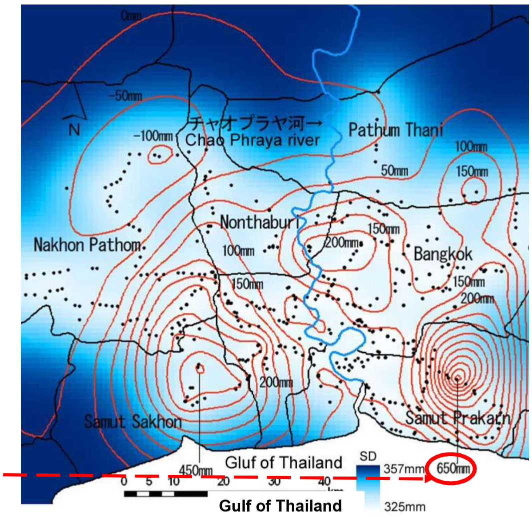


Case of Chao Phraya Delta, Thailand (adapted from Murakami et al., 2004)

Case study: Chao Phraya Delta, Thailand (from Murakami and Yasuhara, 2011).

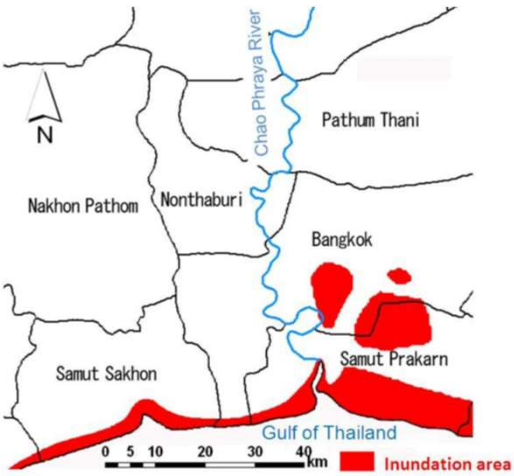


(a) Contour lines of land subsidence in Chao Phraya Delta (from Murakami et al, 2004).

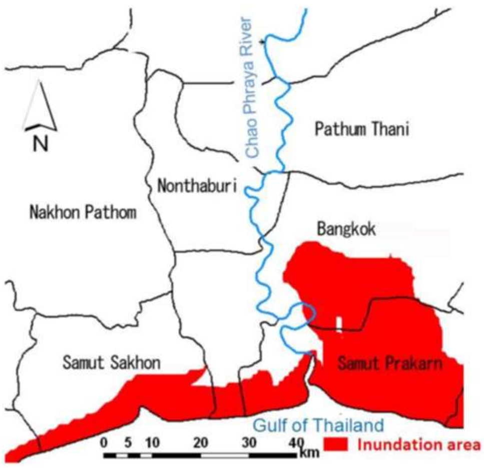


(b) Contour map of the interpolated future and subsidence (from Murakami et al., 2004).

Assessing the Influences of Dual Effects of SLR and Land Subsidence on Inundation Areas (from Murakami et al., 2011)

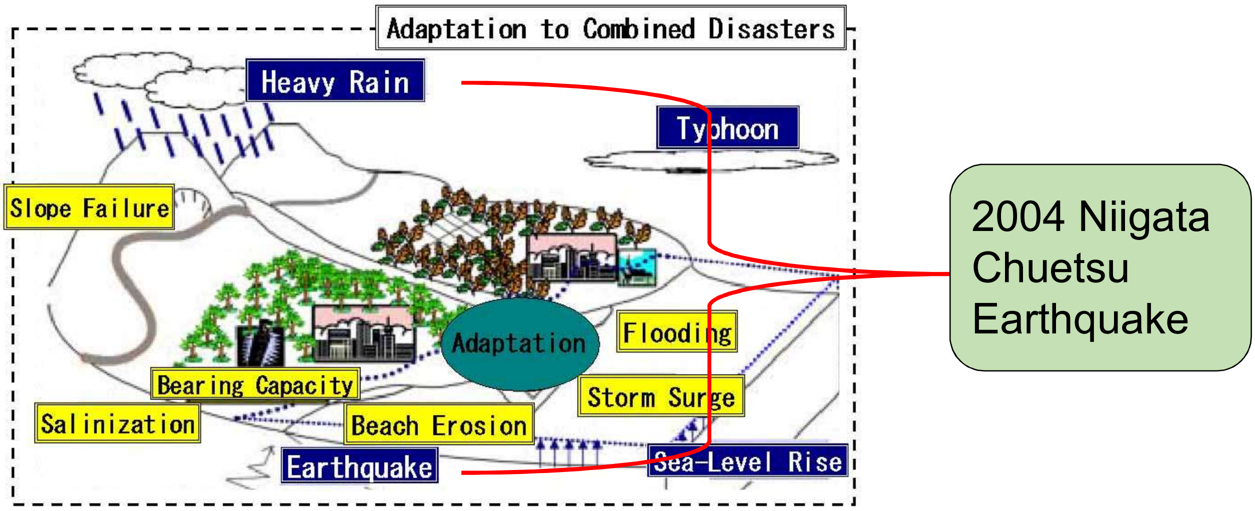


(a) Inundation area caused only by sea-level rise



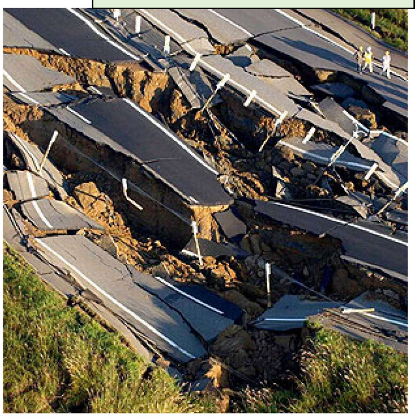
(c) Inundation area caused by sea-level rise and land subsidence with estimation error

Combined torrential rainfall with earthquake （猛烈な雨と地震の複合：2004年　新潟中越地震）



Typical Example of Compound Disasters: Niigata-Chuetsu Earthquake in 2004

(a) Derailment of *Shinkansen* (right) （新幹線の脱線）

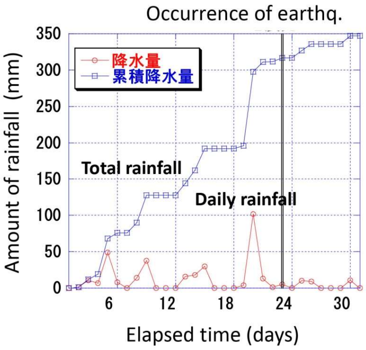


(b) Complete collapse of highway's embankment (Left)

（高速道路盛土の崩壊）

Mechanism of Slope Failure Caused by Earthquake and Abnormal Rainfall

(a) Rainfall in October, 2004



(b) Main shock and aftershocks

Main shock or After shock	Month	Magnitude	Seismic intensity
Main shock	23rd Oct.	6.8	7
1st aftershock	"	6.3	Higher 5
2nd aftershock	"	6	Higher 6
3rd aftershock	"	6.5	"
4th aftershock	27th Oct.	6.1	Lower 6

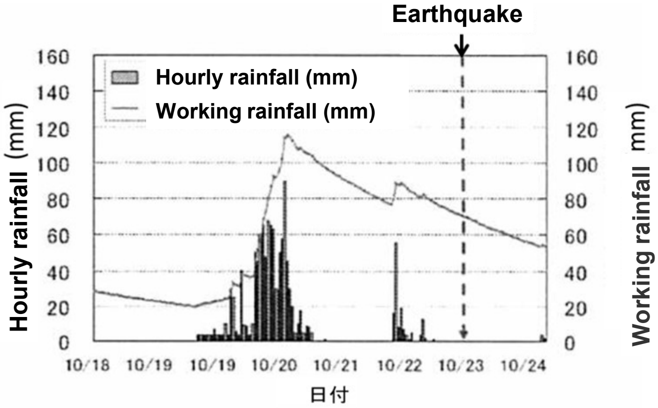
Long-term abnormal rainfall
+ Great earthquake followed by large aftershocks

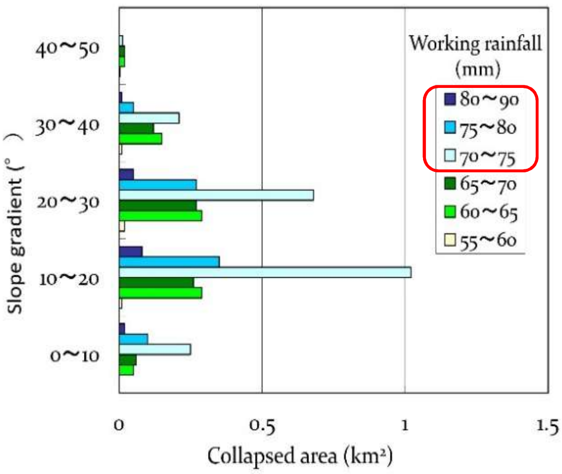
長期にわたる降雨と度重なる余震を伴う大きな地震の複合

Occurrence of slope failures at around 3800 locations

4000か所にわたる斜面崩壊

Mechanism of Slope Failure Caused by Earthquake and Abnormal Rainfall (Nunokawa et al., 2007)





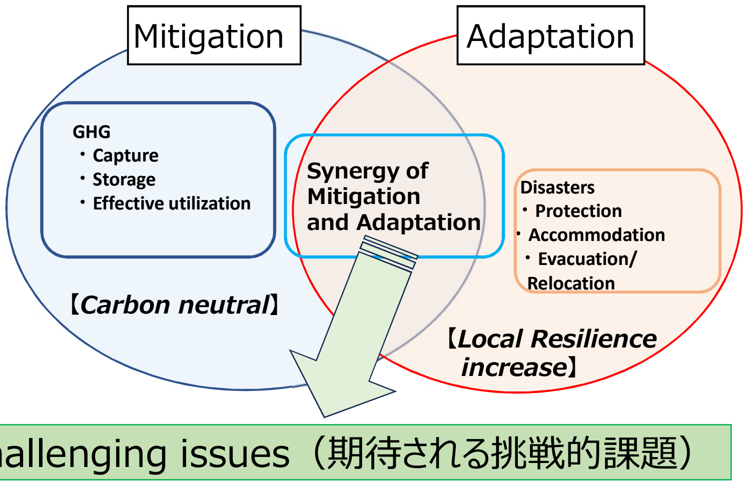
$$R_w = \Sigma_i \, 0.5^{i/T} R_i$$

- **Working rainfall** R_w: Index of precipitation calculated using hourly reduction of the influence of past precipitation

（傾斜の緩やかな斜面の崩壊が顕著）

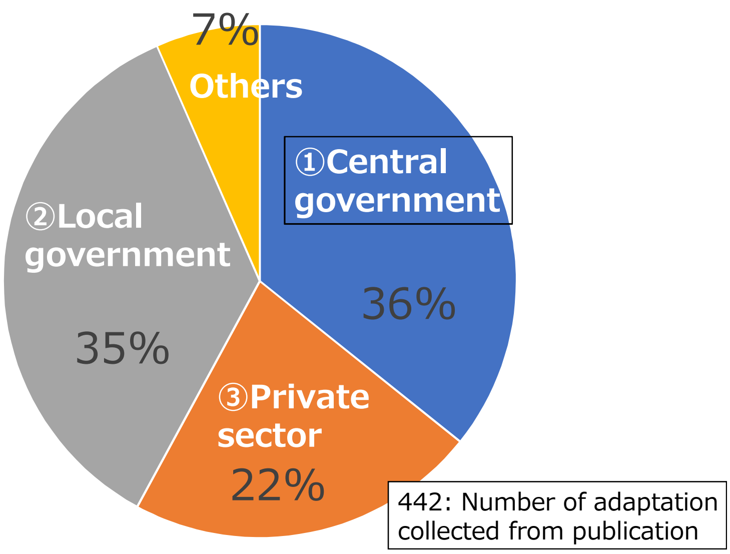
Adaptation Strategies for Climate change-induced Disasters

Climate Change Responses and Their Synergy (気候変動対応策と緩和策と適応策の融合)

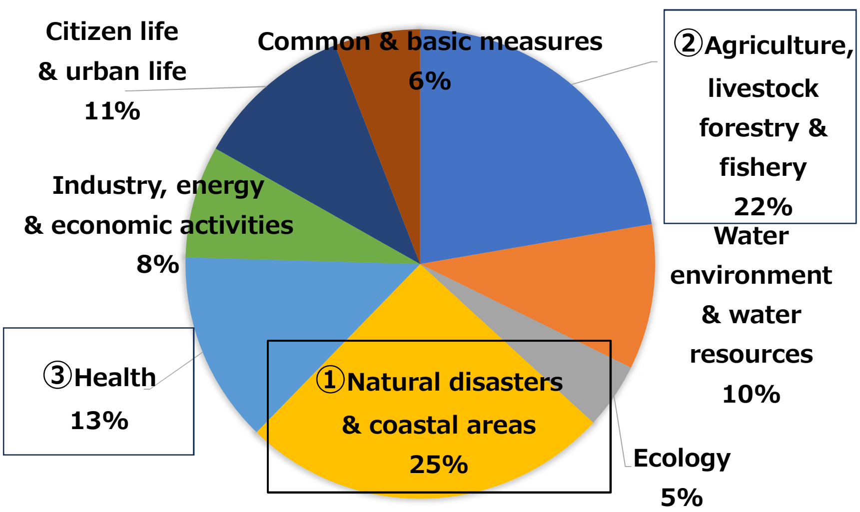


Adaptation strategies are emphasized in today's presentation because the strong focus has been placed too much on mitigation including carbon neutral.

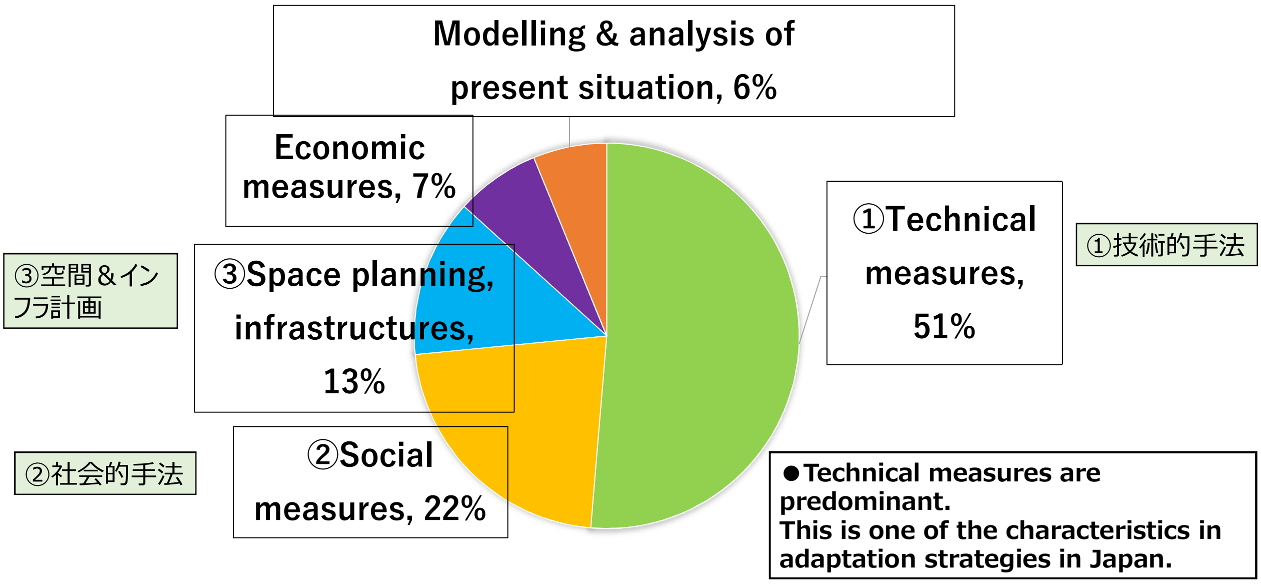
Strategic Situation of Climate Change Adaptation in Japan (by LRRI through Consignment by Ibaraki University)（茨城大学委託業務報告書（2023）による）



7 fields of adaptation in Japan（適応策の７つの分野）

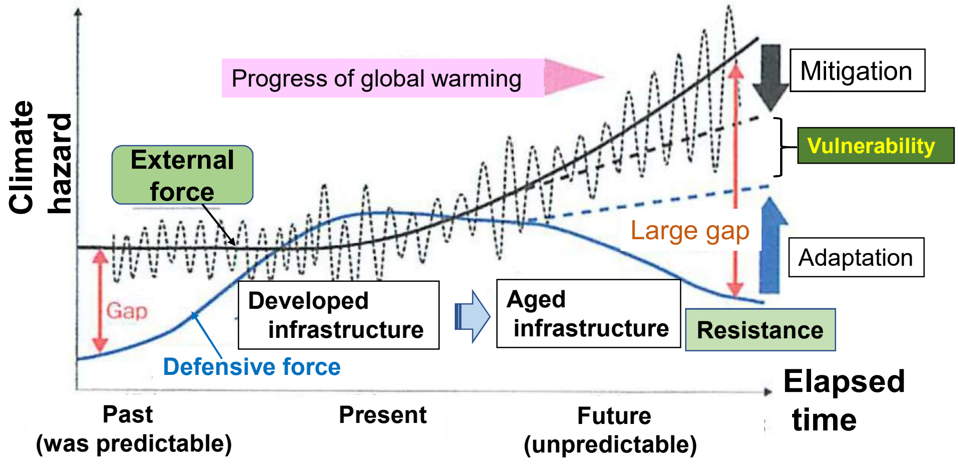


Categories of Adaptation to Natural Disasters （災害に対する手法のカテゴリー）



Increasing Resilience against Climate change-induced Disasters

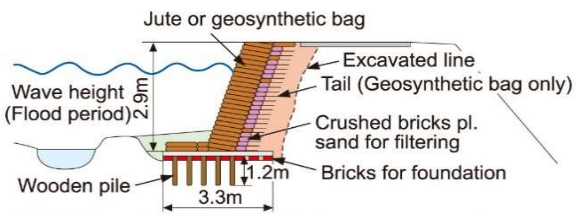
Hazard, Vulnerability ,Adaptation, and Resilience (ハザード，脆弱性，適応＆強靭化)



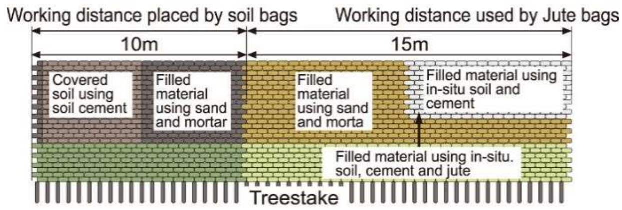
from Komatsu et al. (2014)

Resilience shrinks vulnerability

A Successful Case Study in Bangladesh for Road Embankment Using Jute (Matsushima et al., 2011)

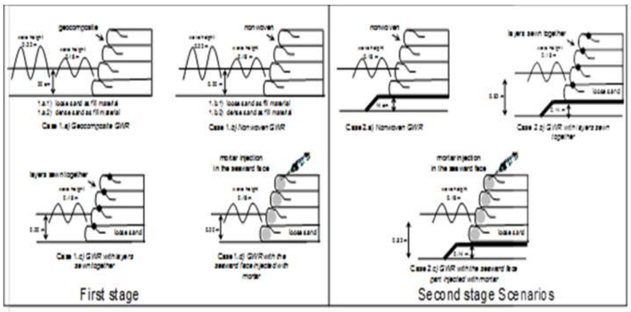


(a) Profile of erosion control work using soil bags

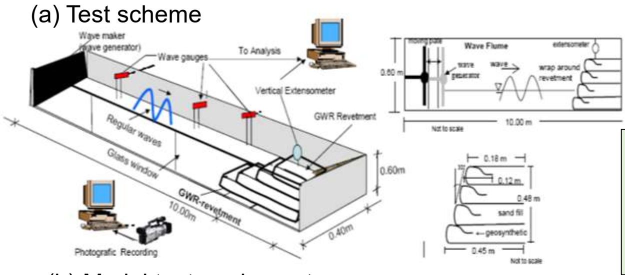


(b)Front view (without inclusion of 3 m rubbing parts)

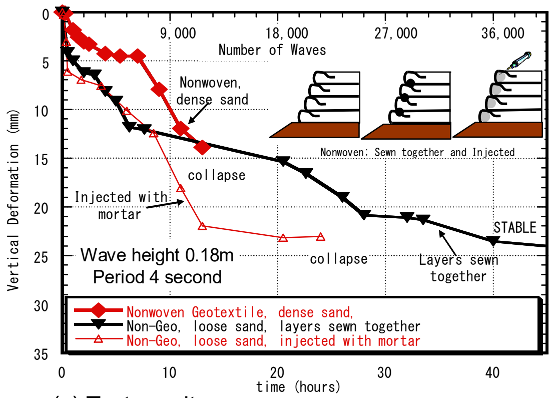
An Example of Hard Mitigation Measure Adopted by Geosynthetics and Cement (Yasuhara and Recio, 2007)



(a) Test scheme



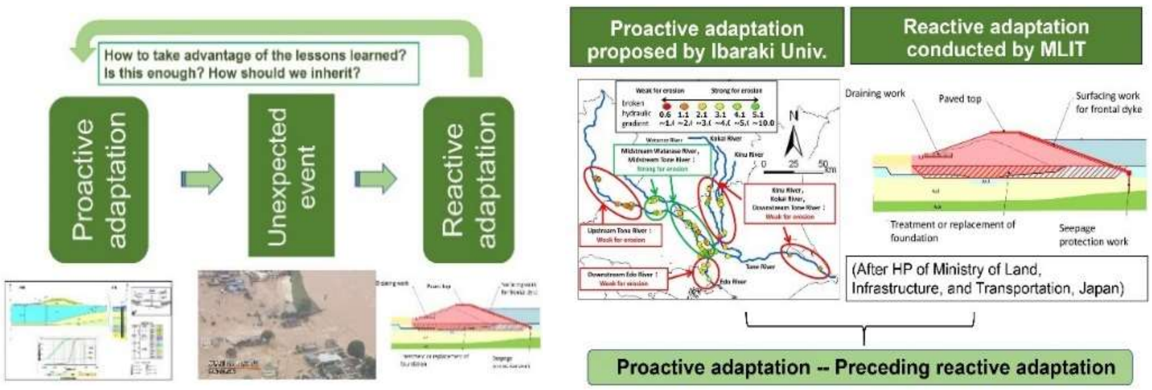
(b) Model test equipment



(c) Test results

The concept is "From Rigid to Flexible Structures"
➢減災対策

From Reactive to Proactive Measures (事後保全から予防保全へ)



Good combination of reactive measures with proactive measures
➢ equivalent to the "adaptive adaptation" concept

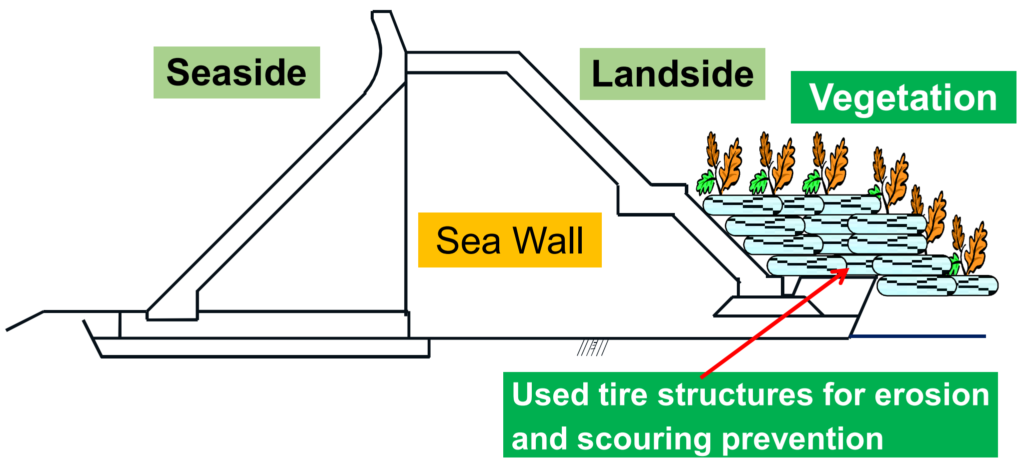
Green Infrastructure (グリーンインフラ)

- **Grey infrastructure**
  Concrete structure/ Geosynthetics ⇒ Protection

- **Green infrastructure**
  ・CO_2 absorption potential in plants ⇒ Mitigation
  ・ Biomass CCS (Recovery storage)
  ・ Utilization of thinned wood and bamboo

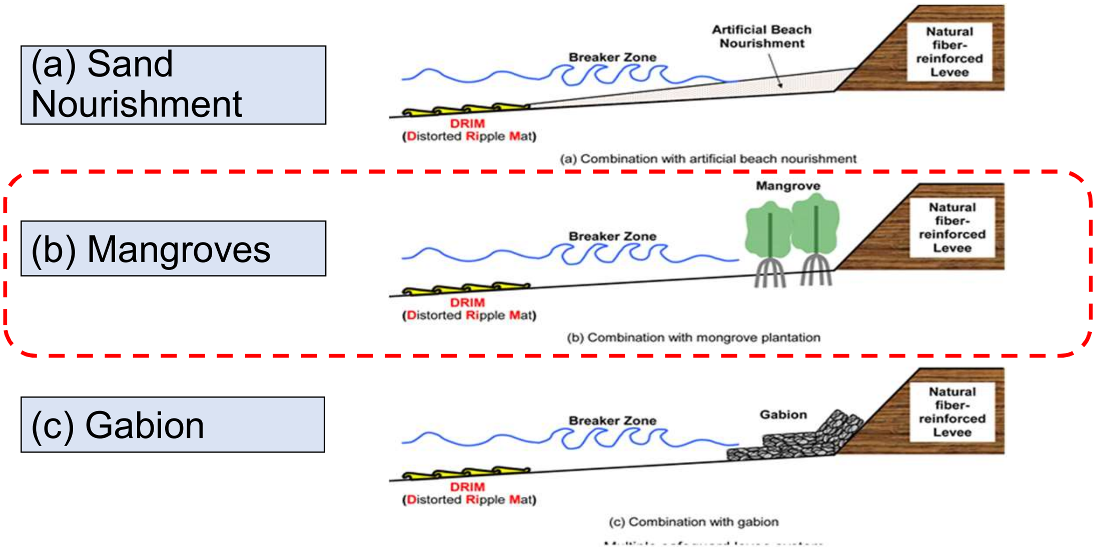
◆ **Synergy of grey infrastructure with green infrastructure**
Must be an example of combination of adaptation and mitigation

Development of Used Tire Application for Coastal Protection （古タイヤの有効利用）

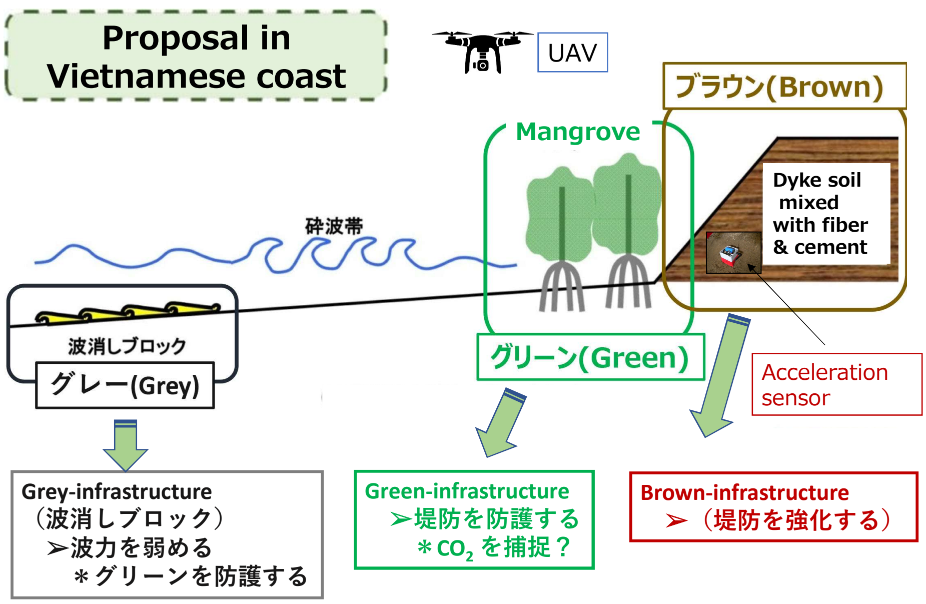


Hazarika and Fukumoto (2016): International Journal of Geomechanics, ASCE

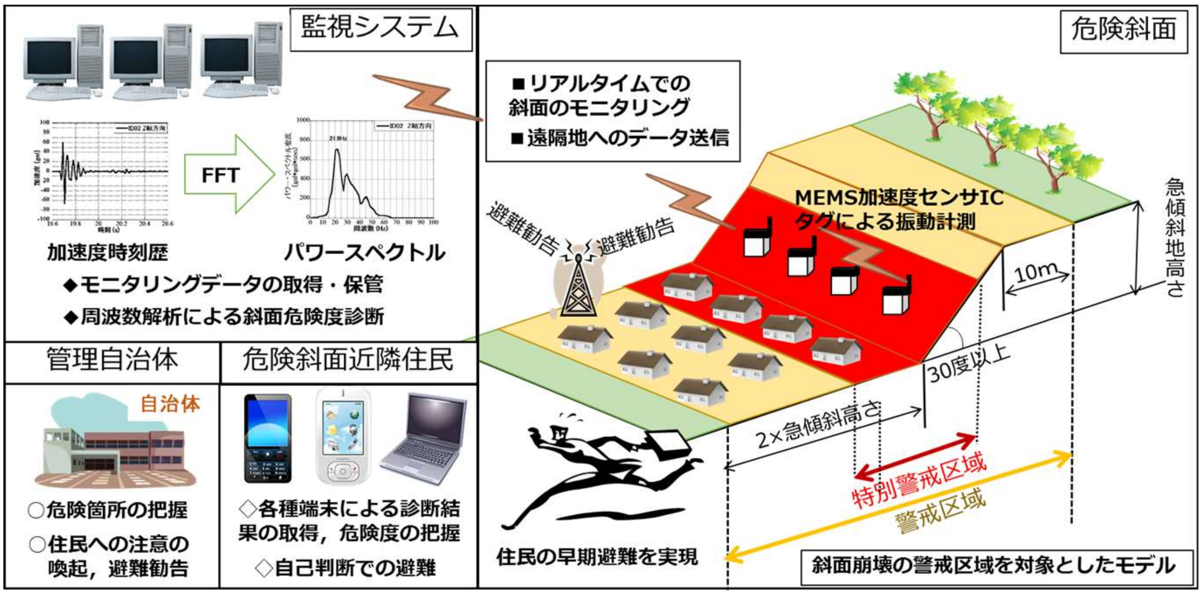
Multi-protection Measures with Green--Grey Infrastructure Synergy in Vietnamese Coasts (Yasuhara, 2016)
（グリーンとグレーの融合による多重防御の例）



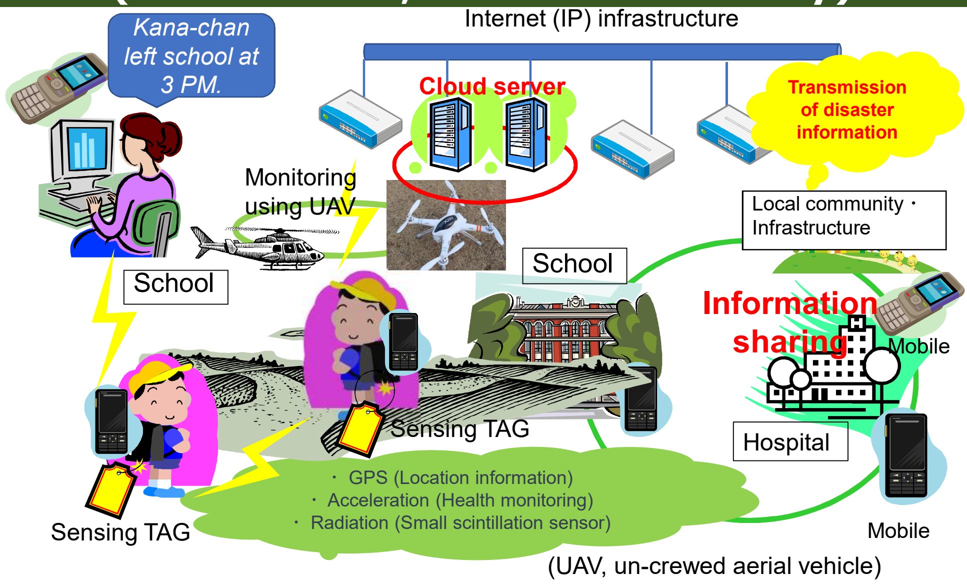
Multiple Protection Based on GGB Concept



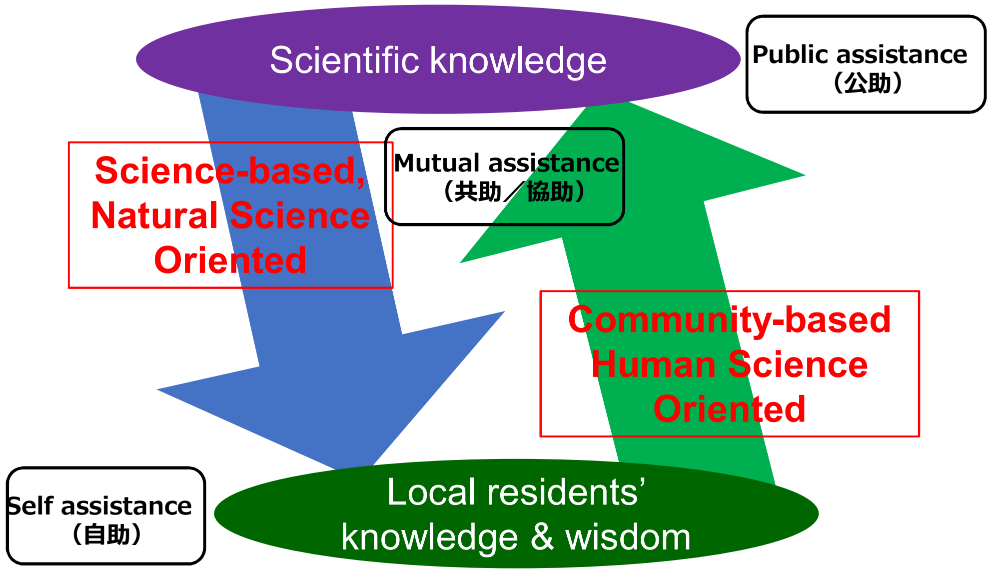
Typical Example: Monitoring System for Slope Stability and Evacuation Using MEMS Sensors (After Saito, Ibaraki University)



Example as Soft Technology for Increasing Local Resilience (After Saitoh, Ibaraki University)



Dual Approach of Adaptation: Top-down and Bottom-up Approaches



Roles of Stakeholders

Public Sector
- Upgrading Monitoring, Impact assessment
- Arrangement of policies related to sediment disasters
- Utilization and reinforcement of existing facilities
- Promotion of early warning, evacuation and crisis management

Private Sector
- Provision of innovative tools, materials and services for disaster prevention
- Participation in monitoring and inspection of existing facilities
- Planning of BCP for crisis management system

Mass media
NGO,NPO

Citizen
- Promotion of self-help and mutual assistance in local community
- Understanding the effective utilization of hazard map
- Participation in disaster prevention training

Researcher & Engineer
- Proposal of innovative methodology
- Integration of philosophy, methodology and information
- Promotion of dissemination and enlightenment from activities of stakeholders

1

Some Keys for Overcoming Extreme & Catastrophic Disasters

◆Scientific aspects
- ➢ Uncertainty ➢ increase certainty

◆Natural environment aspects
- ➢Vulnerability ➢ strengthen resilience

◆Social aspects
- ➢ Myth ➢ should not believe and produce myths
- \- *Shinkansen* (Japanese bullet train) should never collapse
- \- Nuclear power station is safe

◆Human aspects
- ➢ Unpreparedness, Negligence,
- Overconfidence ➢ overcome through education, enhancement and emergence training for and with citizens

Compound Disasters Leading to Catastrophic Disasters

◆ **Unexpected (disasters) – *Souteigai "想定外"***

➢ Disaster beyond what one would expect

◆ **Unprecedented (disasters) – *Mizou "未曾有"***

➢ The most disastrous event that has ever been recorded

We, researchers, should not allow mass-media to use these expressions too frequently.

Challenges for Increasing Geotechnical Engineering's Role in IPCC
（地盤工学のIPCC への貢献の挑戦）

Some Activities of Geotechnics for Climate Change

Year From	Year To	Activity	Country	Reference
2002	2012	Research as CoE on Climate Change-induced Geo-disasters	Norway	Carried out at Norwegian Geotechnical Institute (NGI). The representative is Dr. Farokh Nadhim.
2005	2009	Strategic project on climate change adaptation called S-4	Japan	Supported by Ministry of Environment
2010	2014	Strategic project on climate change adaptation called S-8	Japan	Supported by Ministry of Environment
2013	Present	Asian Technical Committee (ATC1) on Geotechnical Mitigation and Adaptation to Climate Change-Induced Geo-disasters in Asia-Pacific Regions	Asia	Activity of ATC1 is included in International Society of Soil Mechanics & Foundation Engineering
2013	2014	Research Committee on Synergy of Geo-disaster Risk management and Climate Change Adaptation	Japan	Organized by Japan Geotechnical Society (JGS) and chaired by Professor Hemanta Hazarika (Kyushu University)
2014	2015	Course on Global Warming-induced Geo-environments and Geo-disasters	Japan	Journal of Japan Geotechnical Engineering (in Japanese)
2016	2016	56th Rankine Lecture entiled Geotechnics,Energy and Climate Change	UK	Delivered by Professor Richard Jardine (Imperial College) under Organisation by British Geotechnical Association
2016	2016	Symposium on Climate Change-induced Geo-disaster Risk in Snowy Regions	Japan	Organized by Hokkaido Branch of JGS which was chaired by Professor Tatsuya Ishikawa of Hokkaido University
2017	2017	2017 PGS Workshop &15th G. A. Leonards Lecture on Climate Change & Geotechnical Engineering	USA	Held at Purdue University
2018	2018	Special Issue on Climate Change & Geotechnical Engineering	Thailand	Journal of Southeast Asian Geotechnical Society (SEAGS) & Association of Geotechncal Societies in South East Asia (AGSSEA), Vol. 47, No. 1
2019	Present	Colloborative Geotechnical Research Group in Branches of Hokkaido & Kyushu	Japan	Under the support from Geotechnical Research Committee in Japanese Society of Civil Engineers (JSCE)
2020		1st International Conference on CONSTRUCTION RESOURCES FOR ENVIRONMENTALLY SUSTAINABLE TECHNOLOGIES (CREST 2020)	Japan	Climate change is a topic.
2023		9th International Conf. on Environmental Geotechnics	Greece	Climate change is raised up as a topic for the first time.
2023		CREST 2023	Japan	Climate change is a topic.

56th Rankine Lecture given by Prof. R. Jardine, Imperial College, UK, entitled **"Geotechnics, energy and climate change" 2016**

◆ **Part 1** specifically examines support of offshore hydrocarbon production.

◆ **Part 2** describes investigations into the geotechnical impact of climate change in a permafrost region and a peatland study that contributes to alleviating flood risks exacerbated by climate change.

◆ **Part 3** outlines research that is improving the economics of renewable offshore wind energy for multi-pile and monopile supported turbines.

There can be no doubt that his lecture raises a profound challenge!

Constitution of IPCC: Three Working Groups

◆ WGI: provides scientific information related to the global community to meet challenges posed by climate change.

◆ WGII: assesses impacts of climate change from a world-wide to a regional view of ecosystems and biodiversity, and of humans and their diverse societies, cultures and settlements.

◆ WGIII: specifically examines climate change mitigation, assessing methods for reducing and removing greenhouse gas emissions

(AR5 WG II Part A, 2014)

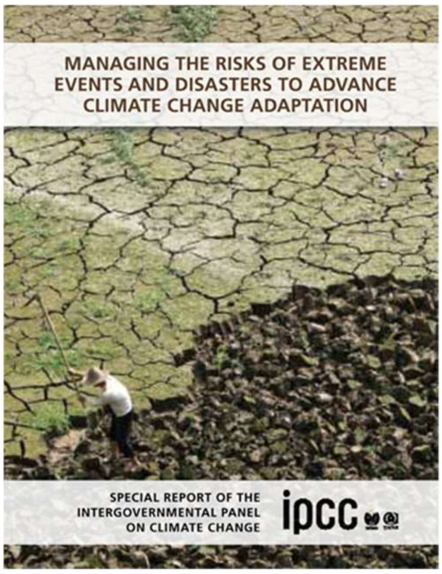
Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX Report)

◆ A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC) published in 2012

◆ Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.).

◆ Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

No references to geotechnical aspects were included!



IPCC and Geotechnical Engineering （IPCC AR には地盤工学的記述はない！）

◆ **From geotechnical perspective**

- Geotechnical findings scarcely reflected in any assessment report
- No keywords such as landslide or land subsidence have been observed in the glossary and index.

◆ **Why? Through experiences as review editors of AR5 (2011--2014)**

・ No authors from geotechnical fields
・ No recognition of geotechnical engineering in academia
・ No recognition of geo-disasters or geo-hazards
・ Low recognition of climate change importance in Geotechnical Society

◆ How should we do this? （どうすべきか？何もしなくてよいか？）
・ Efforts from ICSMGE are needed
・ Strategic submission to journals associated with high IF
・ Not only from academic-oriented studies but also from policy-oriented studies

Summary and Conclusions（まとめ）

This study was conducted to present knowledge and lessons learned from several case studies in different countries in Asia, particularly in Japan. Based on this knowledge and lessons, special emphases have been placed on the importance of ameliorating compound geo-disasters, which include events combined with and without climate change-associated or non-associated factors. For preparation and countermeasures to be pursued in the future, we must acknowledge the following techniques and policies.

i) Greater insight should be sought in relation to proactive rather than reactive measures that underscore the concept of *"adaptive adaptation".*

ii) Such emission resources as used tires and other industrial byproducts should be used to develop adaptive measures. At the same time, locally available materials are the same.

iii) Green infrastructure should be explored to combine with grey infrastructures and brown earth structures.

iv) Geotechnical engineering should/can contribute to international organizations studying climate change, such as the IPCC.

Thank you for your kind attention!

2. 「丸太を用いた液状化対策による気候変動緩和貢献の事例紹介」　村田拓海

Contribution to Climate Change Mitigation of Using Logs for Liquefaction Countermeasures : a Case Study

（丸太を用いた液状化対策による気候変動緩和貢献の事例紹介）

November 20, 2023

Takumi Murata (Tobishima Corporation)

Contents

Contribution to Climate Change Mitigation by using Wood

Effect of mature forest on CO_2 reduction

フレッド・ピアス：写真が語る地球激変，ゆまに書房

Question

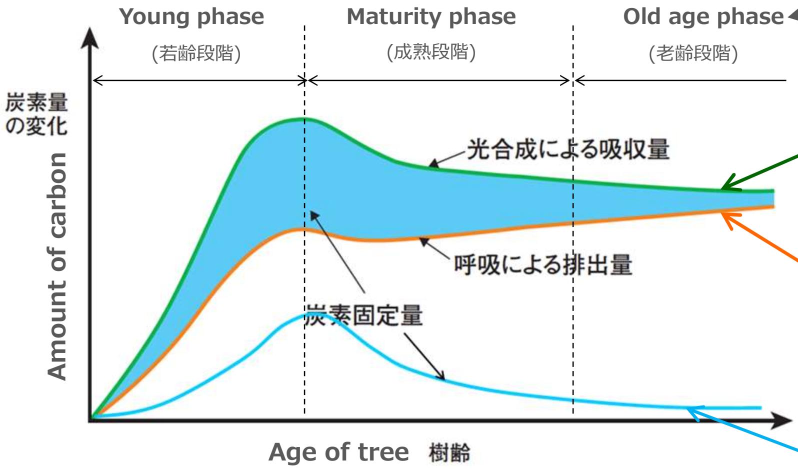
How much does this **mature jungle** contribute to CO_2 reduction from the atmosphere?
(**成熟した森林**はどれくらい大気中のCO_2削減に貢献している？)

Answer

Mature forest **does not contribute to CO_2 reduction** in the atmosphere
(成熟した森林は**大気中のCO_2削減に貢献していない**)

Contribution to Climate Change Mitigation by using Wood

Effect of mature forest on CO_2 reduction



Mature forests will not contribute to CO_2 reduction from the atmosphere

Amount of **carbon absorption** from the atmosphere by photosynthesis

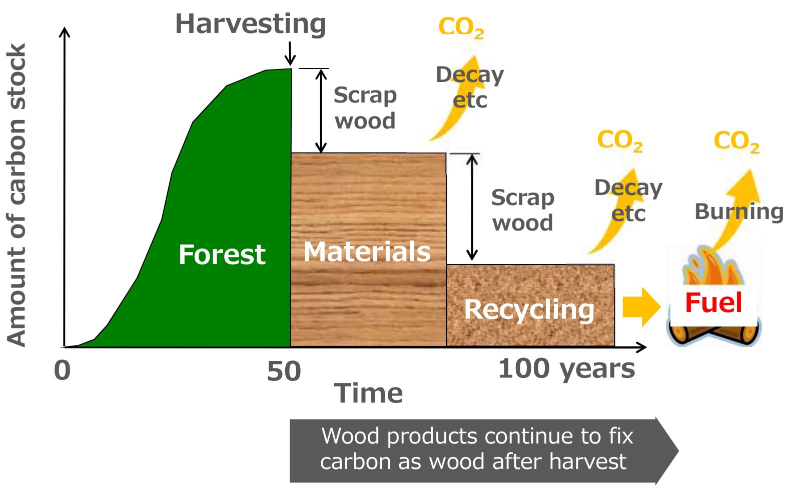
Amount of **carbon emission** due to breathing and decay of fallen branches and leaves

Amount of carbon stock

林野庁：平成25年度森林及び林業の動向・平成26年度森林及び林業施策

Contribution to Climate Change Mitigation by using Wood

Carbon storage and wood use



To increase the total amount of carbon stock, **increasing the amount of trees and wood products** is important.
(炭素ストックの総量を増やすには，樹木や木材製品の量を増やすことが重要)

- ✓ Extend the service life span (長期間の利用)
- ✓ Increase the use of wood products (大量に利用)

Contribution to Climate Change Mitigation by using Wood

Measures to reduce CO_2 from the atmosphere by increasing the amount of wood

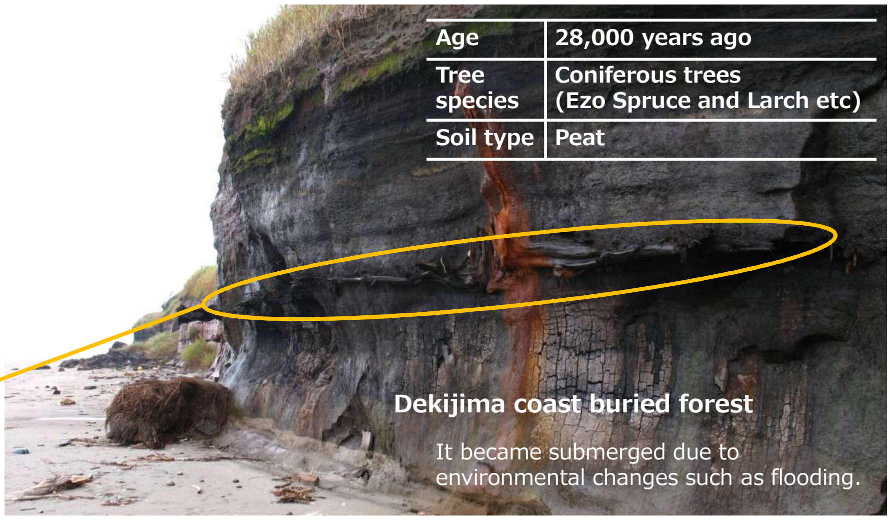
Plant trees and increase the amount of trees
(植林し樹木の数を増やす)

Encourage the growth of trees by thinning and increase the volume of wood
(間伐し樹木の生長を促し材積を増やす)

Use wood products in urban area and increase the total amount of wood
(木材を利用し都市部で木材の総量を増やす)

Contribution to Climate Change Mitigation by using Wood

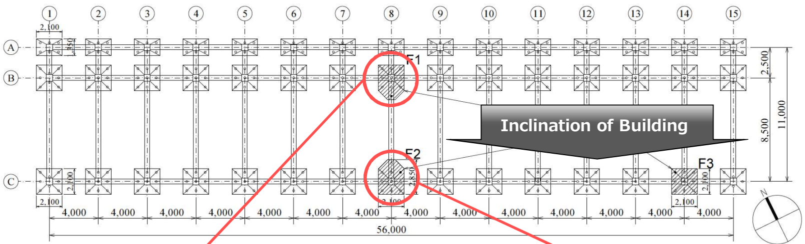
Durability of wood in the ground



Age	28,000 years ago
Tree species	Coniferous trees (Ezo Spruce and Larch etc)
Soil type	Peat

Contribution to Climate Change Mitigation by using Wood

Durability of wood in the ground

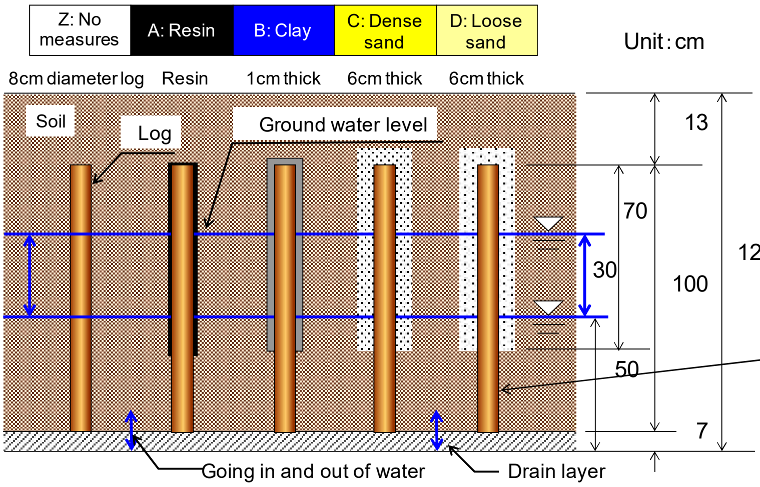


Building Completion	1959
Number of floors	4
Building structure	RC
Building foundation	Pile
Pile type	Wood

Wood placed in the ground is high durability under certain conditions
(ある条件下において，地中の木材は高い耐久性を持つ)

Contribution to Climate Change Mitigation by using Wood

Durability of wood in the ground



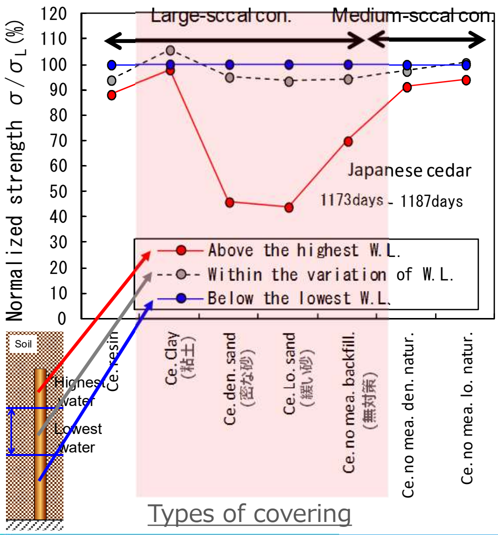
View of large-scale container

100 cm in height,
8 cm in diameter
Tree species:
Cedar and Larch

Schematic cross section of log arrangement in the large-scale container

Contribution to Climate Change Mitigation by using Wood

Durability of wood in the ground



Types of covering

■ Normalized compressive strength of logs after 3 years

$$R_c = \frac{\sigma}{\sigma_L} \times 100(\%)$$

R_c : Normalized compressive strength

σ : Compressive strength at any portion

σ_L : Compressive strength below the lowest water level (Completely sound)

Assumption

- ✓ The strength below the lowest water level, σ_L, keeps the initial strength forever.
- ✓ Scattering within one log is very small.

- ✓ Wood biodeterioration covered with clay does not occur at all even if the wood is higher than the groundwater level.
  (粘土に覆われていれば，地下水位以浅でも生物劣化は生じない)
- ✓ Wood biodeterioration hardly occurs within the changing range of water level.
  (水位変動域では，生物劣化がほとんど生じない)

Contribution to Climate Change Mitigation by using Wood

Characteristics of soft ground

Common feature	Ground type	Time of damage	Occurrence phenomenon	Damage type	
✓ Shallow groundwater level ✓ New deposition ✓ Very soft ✓ No gravel	Clay	Ordinary	Consolidation Slip failure	Settlement Differential settlement Inclination Horizontal displacement, etc.	LP-SoC Method
	Sand	Earthquake	Liquefaction	Settlement Differential settlement Inclination Uplift Horizontal displacement, etc.	LP-LiC Method

Contribution to Climate Change Mitigation by using Wood

Summary

- ✓ **Trees absorb carbon dioxide from the atmosphere, fix carbon, and produce oxygen, so the growth of trees that stock carbon will reduce the carbon dioxide in the atmosphere. Using more products made of wood, which also contain carbon, will reduce carbon dioxide the same as the growth of trees.**

  (樹木は，大気中の二酸化炭素を吸収し，炭素を固定するため，樹木が成長すれば大気中の二酸化炭素を減らすことができる．同じく炭素を含む木材製品を多く使うこととで，樹木の成長と同じように二酸化炭素を減らすことができる．）

- ✓ **Wood has high durability in groundwater, and biodeterioration of wood scarcely occurs within the changing range of water levels. Wood biodeterioration covered with clay does not occur at all even if the wood is higher than the groundwater level.**

  (木材は地下水位以深で高い耐久性を示し，地下水位変動域でも生物劣化はほとんど生じない．地下水位以浅であっても，粘土で覆われていれば生物劣化は生じない．）

- ✓ **Soft ground has always high groundwater level. So, the log in the soft ground can stock carbon almost forever.**

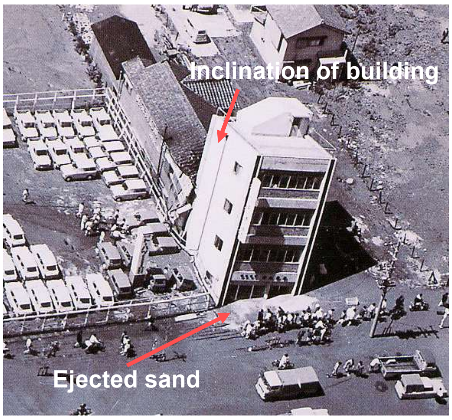
  (軟弱地盤は地下水位が高い．このため，軟弱地盤中の丸太は炭素を半永久的に貯蔵することができる．）

Overview of LP-LiC Method

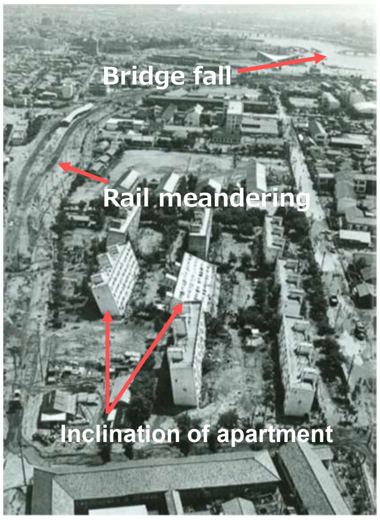
Liquefaction phenomenon

Typical damage due to liquefaction

The 1964 Niigata earthquake



地盤工学会：液状化災害発生直後の新潟市街地航空写真集，1999.2.



新潟日報社：新潟地震から40年～大災害を振り返る～)

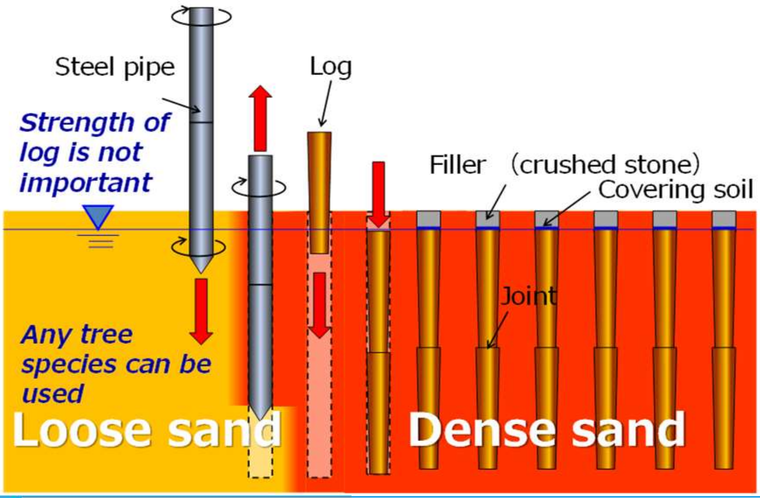
Conditions for occurrence of liquefaction

- ✓ **Sand** (砂)
- ✓ **Dense** (密実)
- ✓ **Saturated with water** (地下水で飽和)
- ✓ **External force** (外力)

Overview of LP-LiC Method

What is LP-LiC method ?

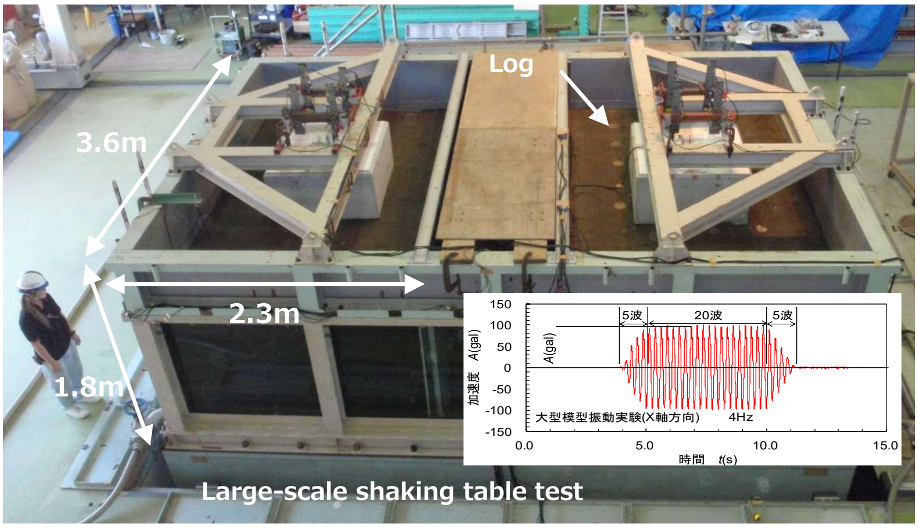
Log Piling Method for Liquefaction Mitigation and Carbon Stock



- ✓ Piling logs improves the ground by densifying the loose sand
  (丸太を地盤に打設することで，緩い砂地盤を密な砂地盤に改良する)
- ✓ Logs below the groundwater level can stock carbon in the ground
  (地下水位以深の丸太は，地中に炭素を貯蔵できる)

Overview of LP-LiC Method

Effect of liquefaction countermeasures by LP-LiC method



Overview of LP-LiC Method

Effect of liquefaction countermeasures by LP-LiC method

Input motion : 150 Gal (157 Gal)
Improvement method : Unimprovement (無対策地盤)

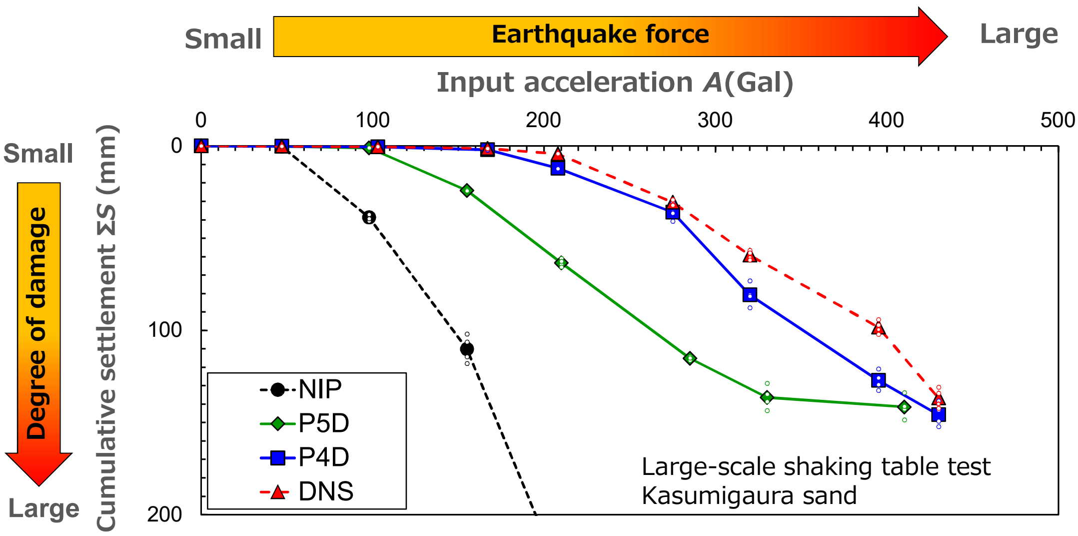
Overview of LP-LiC Method

Effect of liquefaction countermeasures by LP-LiC method

Input motion : 150 Gal (165 Gal)
Improvement method : Log pilling, Pitch = 4D(丸太打設地盤)

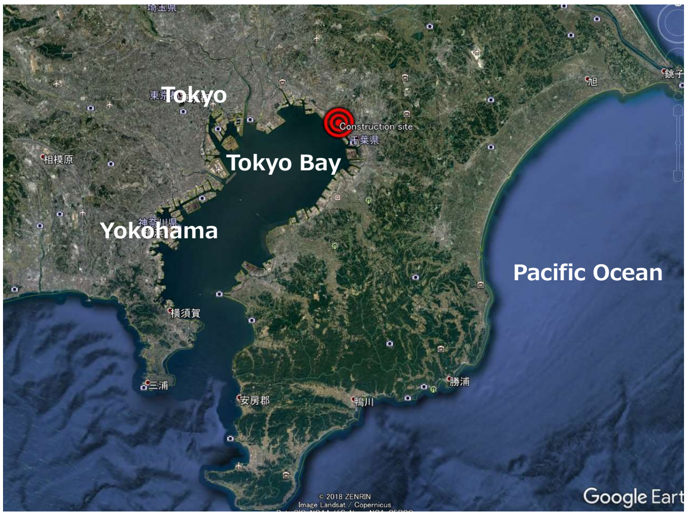
Overview of LP-LiC Method

Effect of liquefaction countermeasures by LP-LiC method



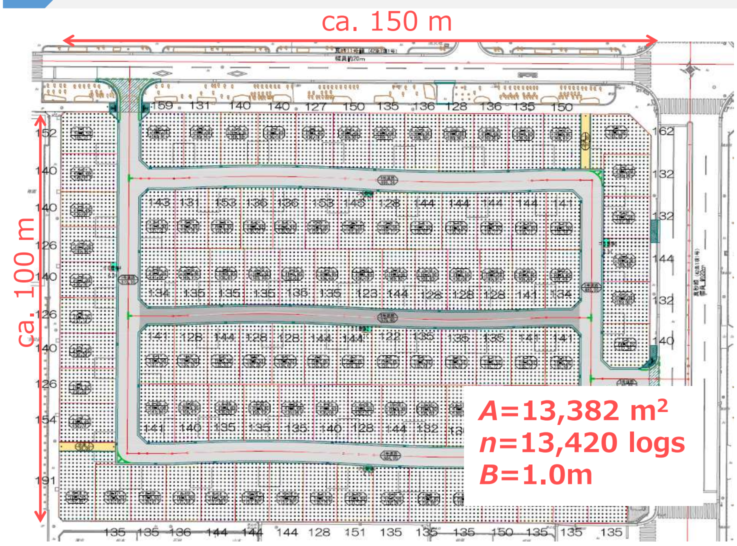
A Case Study of Application to a Large Residential Area

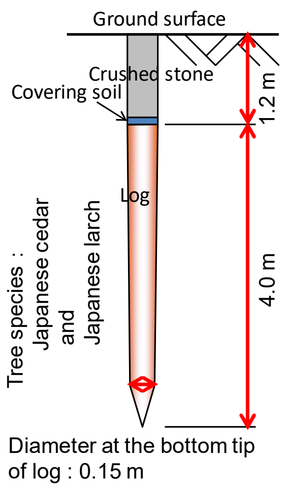
Construction site



A Case Study of Application to a Large Residential Area

Overview of construction



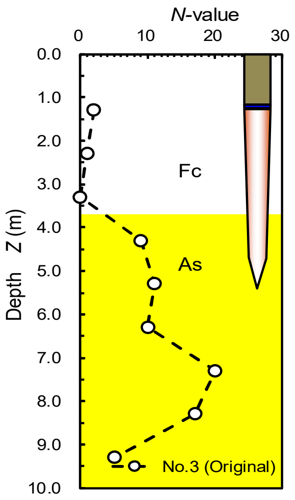


A Case Study of Application to a Large Residential Area

Construction process using LP-LiC method

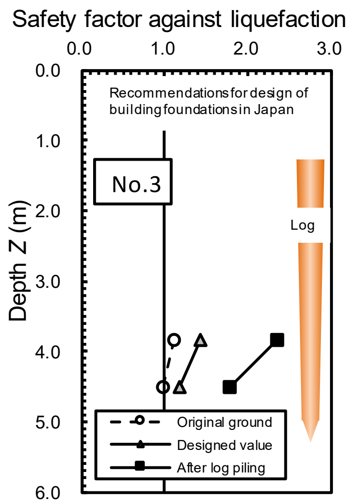
A Case Study of Application to a Large Residential Area

Results of liquefaction countermeasures



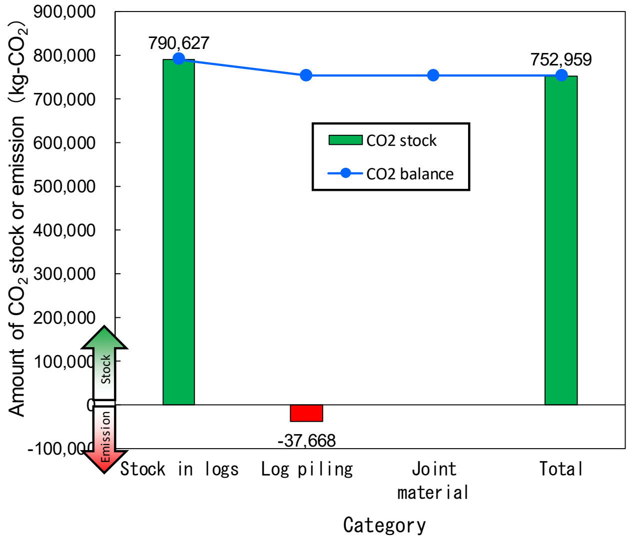
Minimum safety factor F_L against ground liquefaction for each boring site shallower than 5 m

Boring no.	Minimum safety factor F_L against liquefaction (from GL 0.0 m to GL -5.0 m)	
	Original ground	Designed
1	2.46	2.46
2	0.96	1.17
3	0.97	1.18
4	2.40	2.43
5	1.16	1.44



Carbon Storage Effect of LP-LiC method

Application to a Large Residential Area

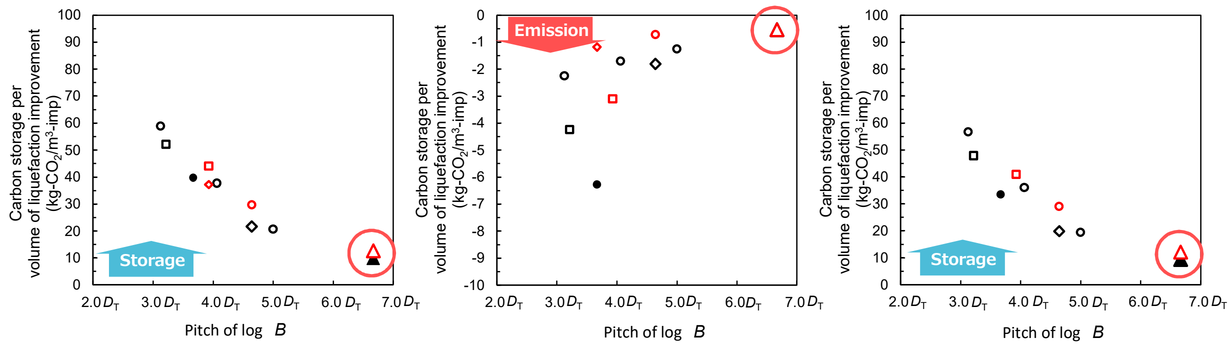


This construction method can contribute to reducing greenhouse gases, as long as planting trees continues after harvest.

(伐採後も植林を続けることで，温室効果ガスの削減に貢献できる)

Carbon Storage Effect of LP-LiC method

Relationship between carbon storage per volume of liquefaction improvement and pitch of logs



Carbon storage by logs + Carbon Emission by construction = Carbon storage by construction

TOBISHIMA CORPORATION

CREST2023 Workshop2 "Practices for Sustainable and Resilient Geotechnology"

Conclusions

- ✓ Trees absorb carbon dioxide from the atmosphere, fix carbon, and produce oxygen, so the growth of trees that stock carbon will reduce the carbon dioxide in the atmosphere. Using more products made of wood, which also contain carbon, will reduce carbon dioxide the same as the growth of trees.

  (樹木は，大気中の二酸化炭素を吸収し，炭素を固定するため，樹木が成長すれば大気中の二酸化炭素を減らすことができる．同じく炭素を含む木材製品を多く使うこととで，樹木の成長と同じように二酸化炭素を減らすことができる．)

- ✓ Wood has high durability in groundwater. So, the log in the soft ground can stock carbon almost forever.

  (木材は地下水位以深で高い耐久性を示す．このため，軟弱地盤中の丸太は炭素を半永久的に貯蔵することができる．)

- ✓ The carbon stock effect of LP-LiC was found to exceed the amount of CO_2 emitted as a result of the construction work by more than a factor of 10, and therefore, contributed to a reduction in greenhouse.

  (LP-LiC工法による炭素貯蔵効果は，施工によるCO_2排出量の10倍以上となり，温室効果ガスの削減に大きく貢献する．)

Thank You for Your Attention !

(ご清聴ありがとうございました！)

TOBISHIMA CORPORATION CREST2023 Workshop2 "Practices for Sustainable and Resilient Geotechnology"

3. 「産官学連携による地方都市における木材利用促進と社会貢献」　吉田雅穂

2nd International Conference on Construction Resources for Environmentally Sustainable Technologies: CREST 2023
October 20th, 2023, Fukuoka International Congress Center

Promoting the utilization of wood in regional cities and contributing to society through industry–government–academia collaboration

産官学連携による 地方都市における木材利用促進と社会貢献

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福井県木材利用研究会会長
福井工業高等専門学校教授

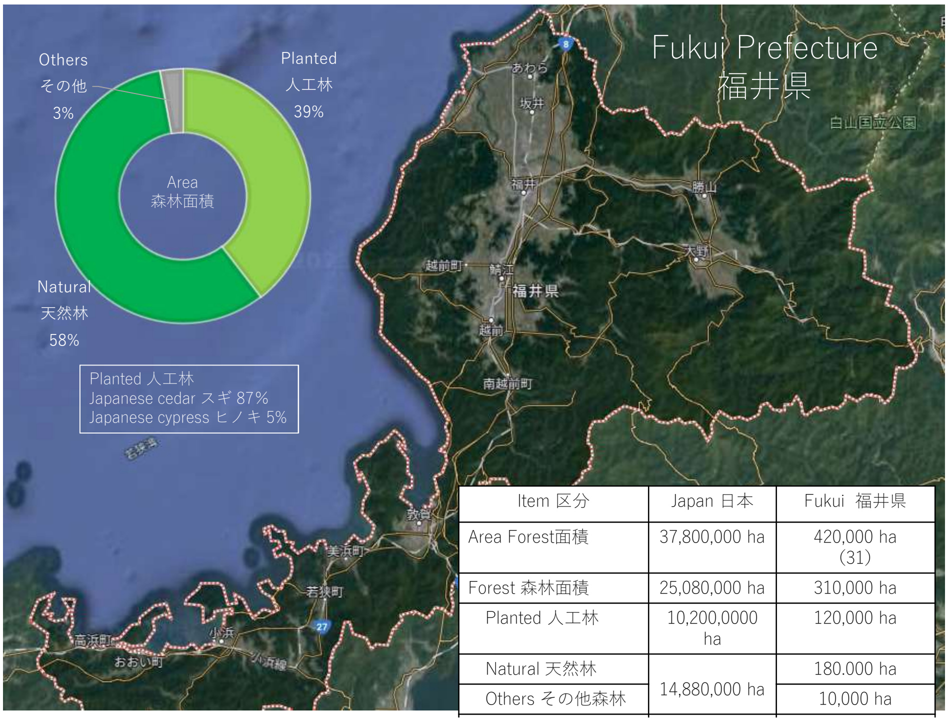
Research Society of Wood Utilization in Fukui 福井県木材利用研究会

Establishment　発足
April 2010　2010年4月

Purpose　目的
To promote the use and stable supply of wood in the fields of civil engineering, architectur and biomass, and to conduct surveys and research, dissemination and awareness-raising, and various activities to promote cooperation and coordination among related parties.
「土木」，「建築」，「バイオマス」の各分野における，木材の利用拡大と安定供給を図ること目的に，調査・研究，普及・啓発，関係者の連携・協調を促進するための様々な活動を行う．

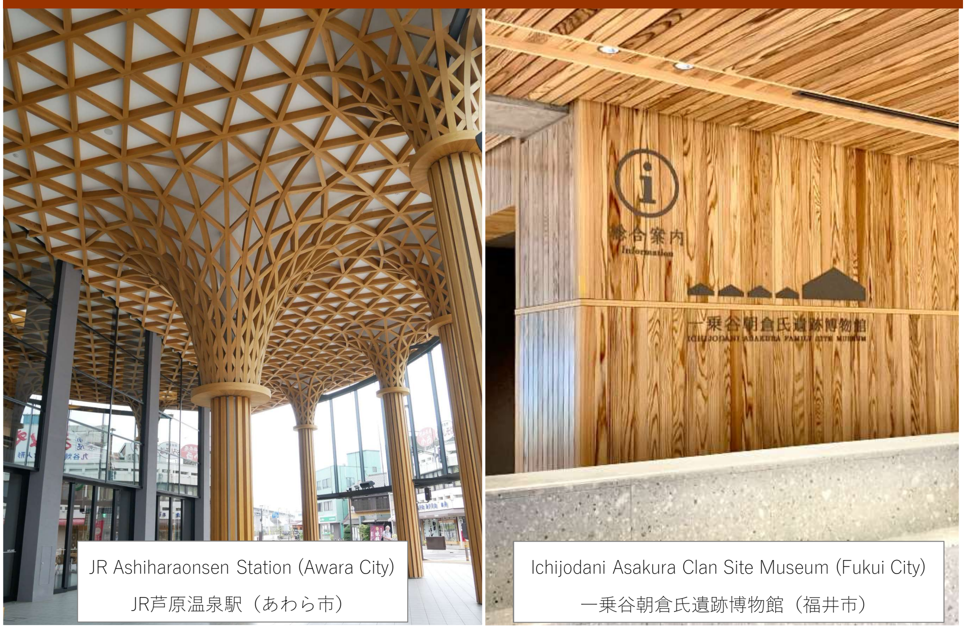
Subcommittees　分科会
Civil engineering, Architecture, Stable supply and biomass
土木系，建築系，バイオマス安定供給

Number of members　会員数
63 people / 29 (25 Companies), 16 (9 Public organizations), 15 (10 local governments), 3 (2 Schools)
63人／企業29人（25社），公的団体16人（9機関），地方自治体15人（10機関），学校3人（2機関）



Item 区分	Japan 日本	Fukui 福井県
Area Forest面積	37,800,000 ha	420,000 ha (31)
Forest 森林面積	25,080,000 ha	310,000 ha
Planted 人工林	10,200,0000 ha	120,000 ha
Natural 天然林	14,880,000 ha	180.000 ha
Others その他森林		10,000 ha

Use of Wood in Architecture
建築における木材利用



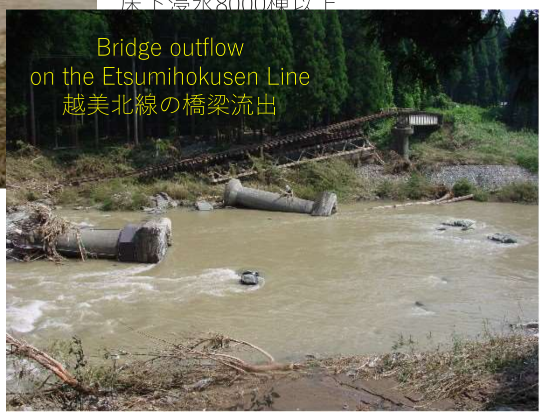
JR Ashiharaonsen Station (Awara City)
JR芦原温泉駅（あわら市）

Ichijodani Asakura Clan Site Museum (Fukui City)
一乗谷朝倉氏遺跡博物館（福井市）

The reason for the establishment of the research society
研究会発足のきっかけ

Heavy rain fall in Fukui on July 18, 2004
2004年7月18日福井豪雨

<u>人的被害</u>
死者4人， 行方不明者1人， 負傷者9人
<u>住家被害</u>
全壊69棟， 半壊140棟， 一部破損229棟
床下浸水8000棟以上



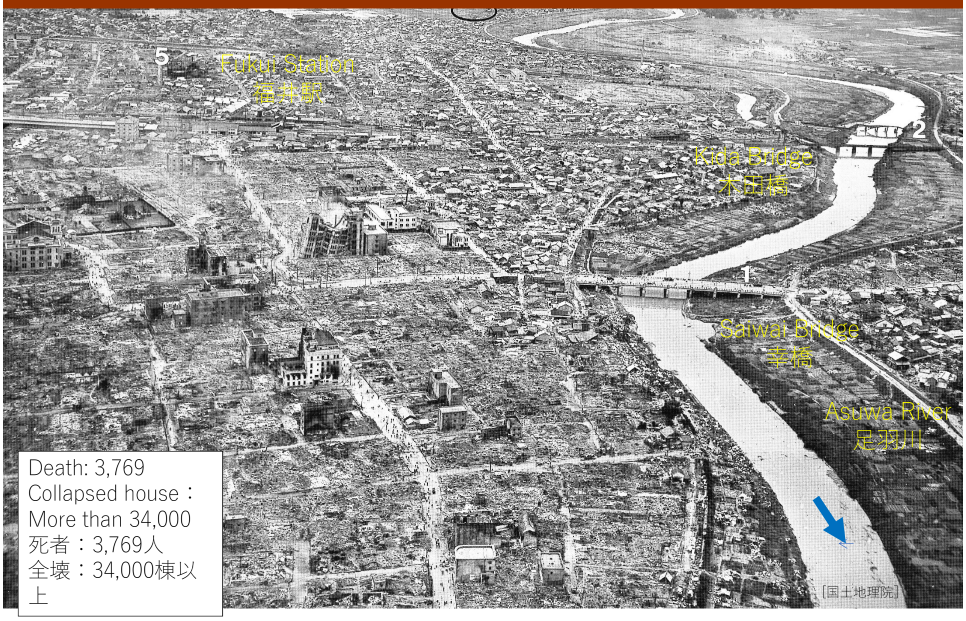
<u>Casualties</u>
4 dead, 1 missing, 9 injured
<u>Damage to houses</u>
Totally destroyed 69, partially destroyed 140, partially damaged 229 , More than 8,000 houses flooded under the floor

Excavation survey of wooden piles at Saiwai Bridge
幸橋の木杭の掘り出し調査

Completion in 1933, 4th generation, RC bridge
1933年竣工，4代目，RC橋

Length 杭長：　1.4m～5.7m
Diameter 直径：　17cm～20cm
Type 樹種：　Pine マツ科マツ属
Year 埋設期間：　74年（1932～2006）
Number 打設本数：90本
Interval 打設間隔：　0.9～1.0m

Saiwai Bridge withstood the 1948 Fukui Earthquake (M7.1)
1948年福井地震（M7.1）に耐えた幸橋



Death: 3,769
Collapsed house：More than 34,000
死者：3,769人
全壊：34,000棟以上

Full-scale field experiment at Tsuruga Port
敦賀港における実大現場実験

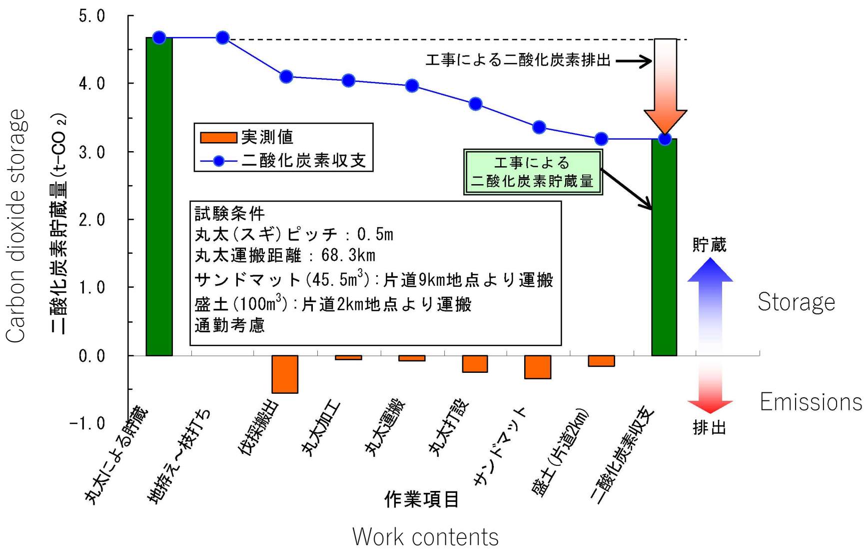
Fukui Prefectural Civil Engineering Department
Tobishima Corporation
National Colldge of Technology, Fukui Colledge
Kobe University
福井県土木部
飛島建設技術研究所
福井工業高等専門学校
神戸大学

Creation of artificial soft ground
人工軟弱地盤の作製

Fine fractionated sandy gravel (gravel: 41%, sand: 28%, fine sand: 31%)
細粒分質砂質礫（礫分：41%，砂分：28%，細粒分：31%）

Construction status on site
現場の施工状況

Carbon storage of wood and carbon dioxide emissions from operations
丸太の炭素貯蔵量と作業による二酸化炭素排出量



Social changes in wood utilization
木材利用に関する社会の変化

平成9（1997）年 京都議定書 Kyoto Protocol

平成16（2004）年　福井豪雨 Fukui Heavy Rain Fall

平成19（2007）年　土木における木材の利用拡大に関する横断的研究会　発足
Cross-sectional Study Group on Expanding the Use of Wood in Civil Engineering is established.

平成21（2009）年　土木学会木材工学特別委員会　設置
Special Committee on Wood Engineering of the Civil Engineering Society Setting

平成22（2010）年　「公共建築物等における木材の利用の促進に関する法律」
Act on Promotion of Utilization of Wood in Public Buildings, etc.

平成22（2010）年　福井県木材利用研究会　発足
Research Society of Wood Utilization in Fukui is established.

平成23（2011）年　東日本大震災 Great East Japan Earthquake

平成24（2012）年　土木学会木材工学委員会　発足
The Civil Engineering Society, Wood Engineering Committee is established.

平成25（2013）年　「国土強靭化基本法」 Basic Act for National Resilience

令和3（2021）年 「脱炭素社会の実現に資する等のための
建築物等における木材の利用の促進に関する法律」
Act on Promotion of Utilization of Wood in Buildings, etc. to Contribute to Realization of a Decarbonized Society, etc.

Activities of Research Society of Wood Utilization in Fukui
福井県木材利用研究会の活動

Wood Utilization Symposium in Fukui
木材利用シンポジウムin福井

December 6, 2020
Fukui International Activities Plaza
164 participants
2020年11月6日
福井県国際交流会館
参加者**164名**

December 11, 2010
Fukui International Activities Plaza
200 participants
2010年12月11日
福井県国際交流会館
参加者200名

Regular study meeting
定例研究会

2023/6/26, Fukui Forest Association
2023/6/26，福井県森林組合連合会

Field trip 見学会

Wood Market
(Fukui Prefecture Wood Market
Cooperative Association, Fukui City)
木材市場
（福井県木材市売協同組合，福井市 ）

Biomass Power Plant
(Fukui Green Power, Ono City)
バイオマス発電所
（福井グリーンパワー，大野市）

Field trip 見学会

Sound Insulation Wall
(Geba, Fukui City)
遮音壁
（福井市下馬）

Flood control dam
(Miyama-cho, Fukui City)
治山ダム
（福井市美山町）

Field trip 見学会

Fishway
(Kyozen, Eiheiji-cho)
魚道
（永平寺町京善）

Fish Reef
(Iimori, Obama City)
魚礁
（小浜市飯盛）

Wood use seminar for children and their parents
親子で学ぶ木材利用セミナー

15 pairs of parents and children from inside and outside of the prefecture, 40 people in total
県内外より15組計40名の親子

Wood utilization exhibition in Fukui City
福井市木材利用展示会（2023年10月2～6日）

Panels introducing Research Society of Wood Utilization in Fukui and products of member companies
福井県木材利用研究会の紹介パネルと会員企業の製品

Received the JSCE Kansai Branch Regional Activity Award for 2021
2021年度土木学会関西支部　地域活動賞　受賞

April 14, 2022, Construction Exchange Meeting (Osaka City, Osaka Prefecture)
2022年4月14日，建設交流館（大阪府大阪市）

Example of wood utilization for soft ground improvement in Fukui Prefecture

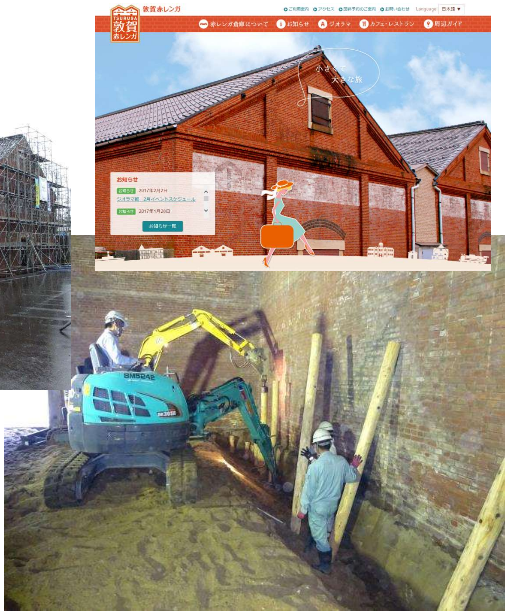
福井県における軟弱地盤対策での木材利用事例

Soft ground improvement for detached house (2013/3/6, Sakai City)
戸建住宅の軟弱地盤対策（2013/3/6，坂井市）

Liquefaction countermeasures for farm building (2016/2/29, Fukui City)
農舎の液状化対策（2016/2/29, 福井市 ）

Diameter 末口径： 15 cm
Length 長　さ： 4 m
Interval 間隔：0.9 m
Number 本数：564 本

Liquefaction Countermeasures for Red Brick Warehouse (2014/8/9, Tsuruga City)
赤レンガ倉庫の液状化対策（2014/8/9, 敦賀市）

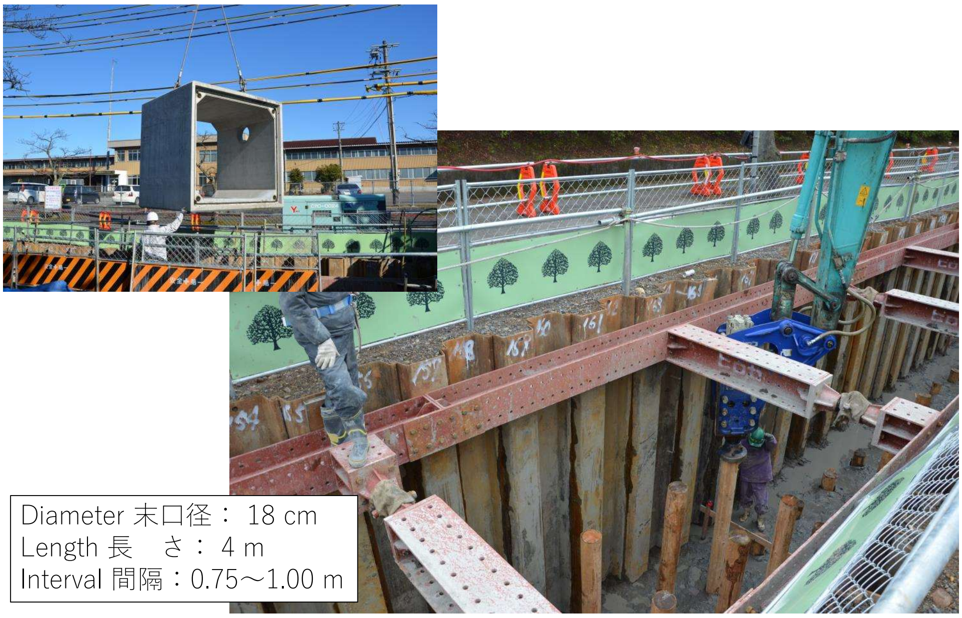


Diameter 末口径： 15 cm
Length 長　さ： 3 m
Number 本数：700 本以上

Soft ground improvement for road body (2011/7/8, Obama City)
道路路体の軟弱地盤対策（2011/7/8, 小浜市）

Soft ground improvement for embankment (2012/4/13, Mikata PA on Wakasa-Maizuru Expressway)
盛土の軟弱地盤対策（2012/4/13, 若狭舞鶴自動車道三方PA）

Soft ground improvement for box culverts (2016/2/4, Sabae City)
ボックスカルバートの軟弱地盤対策（2016/2/4，鯖江市）



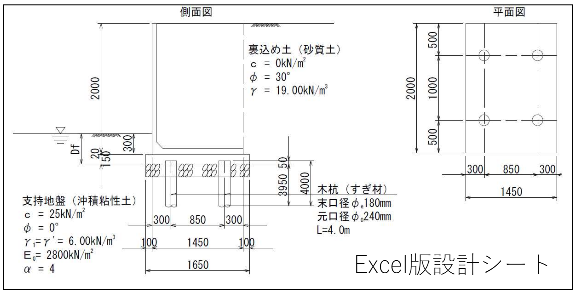
Diameter 末口径： 18 cm
Length 長　さ： 4 m
Interval 間隔：0.75～1.00 m

Soft ground improvement for levees (2020/11/16, Obama City)
堤防の軟弱地盤対策（2020/11/16，小浜市）

Diameter 末口径： 18 cm
Length 長　さ： 4 m x 3本
Number 本数：約7.000 本

Design and construction manual for soft ground improvement using log pile method
丸太杭工法を用いた軟弱地盤対策の設計・施工マニュアル

March 2013 Published
Culvert (3m x 3m),vL-shaped retaining wall (2m), Roadway body
2013年3月刊行
カルバート（3m×3m），L型擁壁（2m），道路路体



Precast L-shaped retaining wall design sheet
Design sheet for precast box culvert
プレキャストL型擁壁の設計シート（土木編，建築編）
プレキャストボックスカルバートの設計シート（土木編）

Seminar for design and construction manual for soft ground improvement using log pile method
丸太杭工法を用いた軟弱地盤対策の設計・施工マニュアル講習会

Research and development of wood utilization technology through industry-government-academia collaboration in Fukui Prefecture

福井県の産官学連携による木材利用技術の研究開発

Industry: Miyama Town Forestry Cooperative
Government: Fukui Prefectural Department of Agriculture, Forestry and Fisheries
Academia: Fukui National College of Technology
産：美山町森林組合
官：福井県農林水産部
学：福井工業高等専門学校

Mechanical properties of saturated wood
飽水木材の力学特性の解明

Mechanical properties of saturated wood
飽水木材の力学特性の解明

Sales of wood made in Fukui Prefecture to Chiayi County, Taiwan

福井県産木材の
台湾嘉義県へのセールス

Industry: Marvel Corporation
Government: Fukui Prefectural Department of Agriculture, Forestry and Fisheries
Academia: Fukui National College of Technology
産：マーベルコーポレーション
官：福井県農林水産部
学：福井工業高等専門学校

Grant for Japan-Taiwan Industrial Cooperation Project
日台産業協力架け橋プロジェクト助成事業

October 12, 2023
Chiayi County Human Resource Development Office, Taiwan
2023年10月12日
台湾嘉義県人力発展所

Conclusions まとめ

“Promoting the utilization of wood in regional cities and contributing to society through industry–government–academia collaboration”

Industrial Promotion and Regional Revitalization
⇒Revitalization of the forestry and lumber industries by promoting the use of lumber in construction projects

National Land Stewardship and Climate Change Mitigation
⇒Carbon stock through measures against soft ground using timber

「産官学連携による地方都市における木材利用促進と社会貢献」

◎産業振興と地域活性化
⇒建設事業での木材利用促進による林業と製材業の活性化

◎国土強靭化と気候変動緩和
⇒木材を用いた軟弱地盤対策によるカーボンストック

4.　「気候変動における持続可能性に関するLRRIの活動」安原一哉

LRRI Activities for Climate Sustainability （気候サステナビリティに関するエルリの活動）

Workshop in CREST 2023 on
“Practices for Sustainable and Resilient Geotechnology”

- **Kazuya YASUHARA, Ph.D.**

- **Representative of Local Resilience Research Institute (LRRI)**
  (Professor Emeritus of Ibaraki University, Japan)

-- November 20, 2023 --

(see https://www.ic-crest.com/)

GLEC Ibaraki University

LRRI Local Resilience Research Institute
(https://lrri.or.jp/)

CREST 2023

Presentation Contents

◆ What is LRRI?（LRRIって何？）

◆ Activities of LRRI（活動内容）

◆ How Should We at LRRI Cope with Climatic Hazards?（LRRIは気候ハザードのどう立ち向かうか？）

◆ **LRRI Technologies for Climate Change Responses（気候変動対応のためのLRRI関連技術）**

◆ Future Outlooks for Climate Change and SDGs at LRRI （気候変動とSDGs対応の将来展望）

Outline of Local Resilient Research Institute (Non-profitable Private Sector : LRRI)

◆ Mission Statement

First Right Second Interest

◆ Corporate Philosophy

Contribution to local resilience increase through knowledge and wisdom of members and support for developing human resources capable of finding and proposing solutions for emerging difficulties, including climate change and SDG related issues.

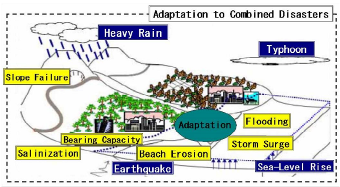
◆ Characteristic Features of the Organization

- Engineering groups with rich humanity and different experiences synergistically organized by senior and middle leaders
- Providing opportunities and platforms on which members and non-members collaborate to find solutions for increasing local resilience
- Providing platforms and lectures by which members and non-members learn fundamental and advanced knowledge about issues including climate change

◆ Corporate Members

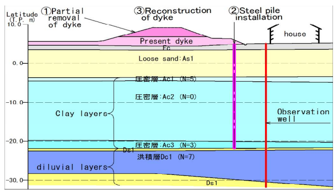
Organization		URL (Home page address)
Japanese	English	
㈱JSP	JSP CO.,LTD.	https://www.co-jsp.co.jp/
アキレス㈱	ACHILLES CORPORATION	https://www.achilles.jp/
イーテック㈱		http://www.earth-techno.co.jp/
エターナルプレザーブ㈱	Eternal Preserve Co., Ltd.	http://www.etp21.co.jp/
岡三リビック㈱	OKASANLIVIC.CO.,LTD.	https://www.okasanlivic.co.jp/
（一社）GLOSS 研究会	Global Society for Smart Geo-Sustainnovation	https://www.geogloss21.org/
昭和コンクリート工業㈱	Showa Concrete Co.,Ltd.	https://www.showa-con.co.jp/
㈱T＆S開発設計事務所	T&S Development Design Co., Ltd	https://www.tands-kaihatsu.co.jp/
㈱高萩エンジニアリング		http://www.t-hagi.co.jp/
地水開発㈱		https://chisui-kaihatsu.co.jp/
東京インキ㈱	TOKYO PRINTING INK MFG CO.,LTD.	https://www.tokyoink.co.jp/
福山コンサルタント㈱	FUKUYAMA CONSULTANTS CO., LTD.	https://www.fukuyamaconsul.co.jp/
PEDI Civil Solutions ㈱	PEDI Civil Solutions	https://pedicivil.com/
水戸グリーンサービス㈱	Mito Green Service Corporation.	http://www.greenservice.jp/
みらい建設工業㈱	MIRAI CONSTRUCTION CO.,LTD.	https://www.mirai-const.co.jp/
メトリー技術研究所㈱	metry Co., Ltd.	http://www.metry.jp/
木材活用地盤対策研究会		https://mokuchiken.com/

Divisions of LRRI for SDGs and Climate Change



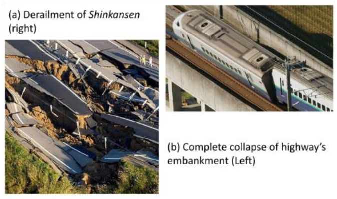
[Consultant Division]
（困難な課題解決応談）

Proposal of solutions for increased local resilience



LRRI

(a) Derailment of *Shinkansen* (right)



(b) Complete collapse of highway's embankment (Left)

[Technical Development Division]
（融合＆連携による新しい技術提案）

Proposal of new technologies and policies for increasing local resilience

[Educational Support Division]
（継続教育，リスキリング支援）

・Support for human resource development through seminar and training programs
・Publication of advanced technology related to local resilience improvement

Background and Roles of LRRI

[Needs through Background]

- Necessity for new policies and technologies for responses to extreme events
- Upgrading engineer and policymaker skills for finding suitable solutions

[Seeds]

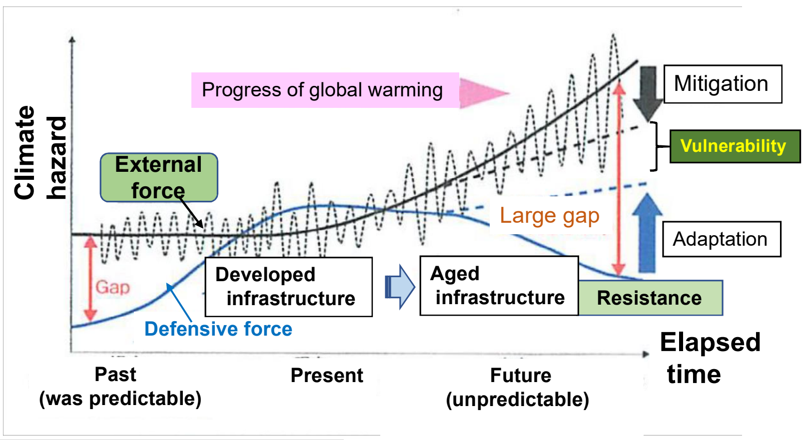
- Existence of potential senior engineers capable of supporting them to find solutions to extreme events and to increase local resilience together with junior and middle engineers

Roles of LRRI

(1) Proposals of solutions for increasing local resilience, (2) Proposals of new technologies and policies for increasing local resilience, (3) Support for human resource development through seminars and training programs, and (4) Book publication

[Profiles of Corporate Officers]

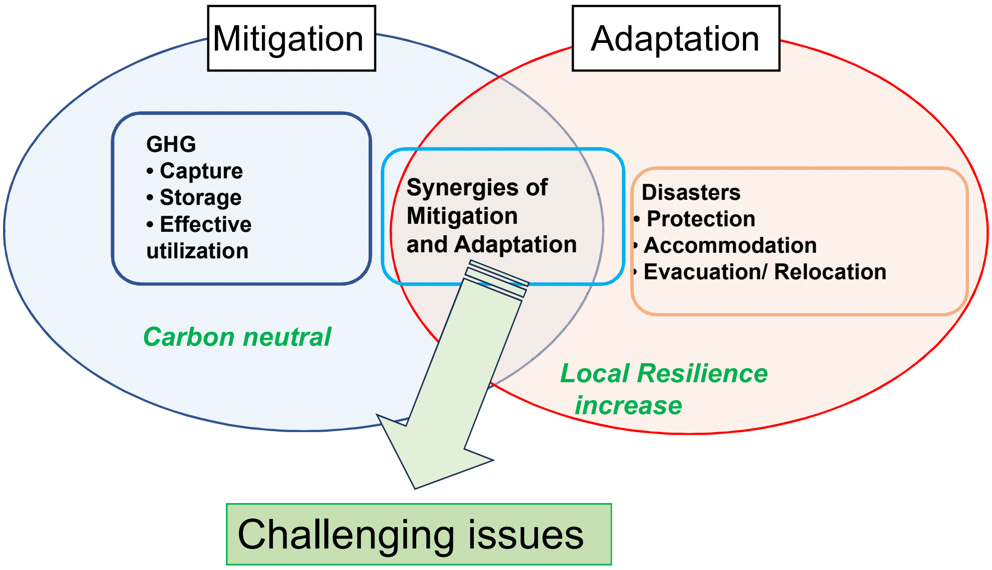
Resilience Enhancement Leading to Achievement of SGGs:What is Resilience? Correlation with Other Keywords



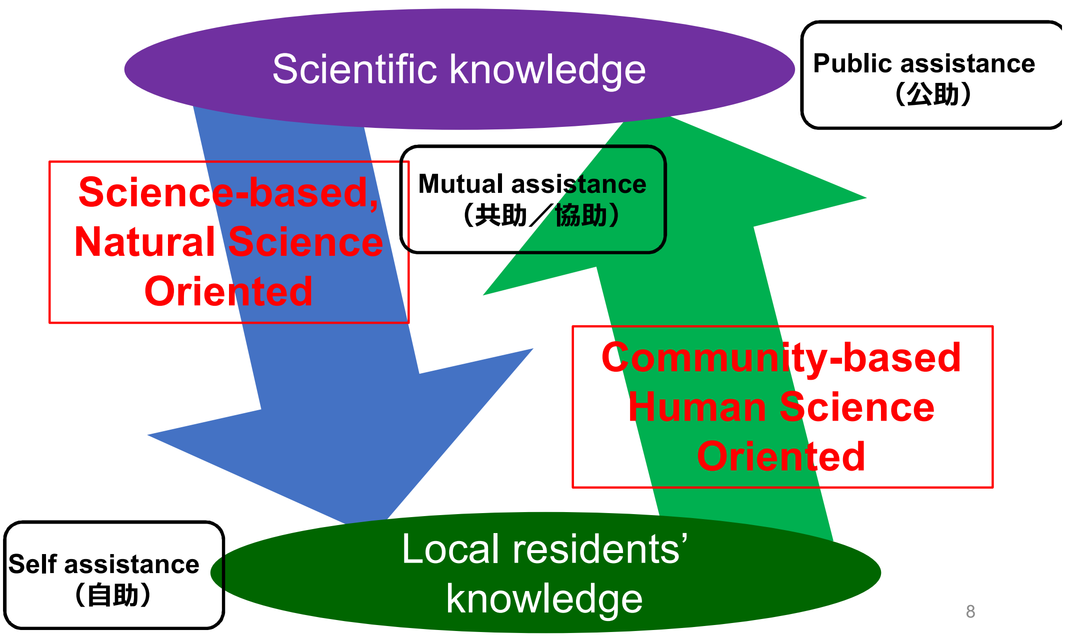
from Komatsu et al. (2014)

Resilience shrinks vulnerability

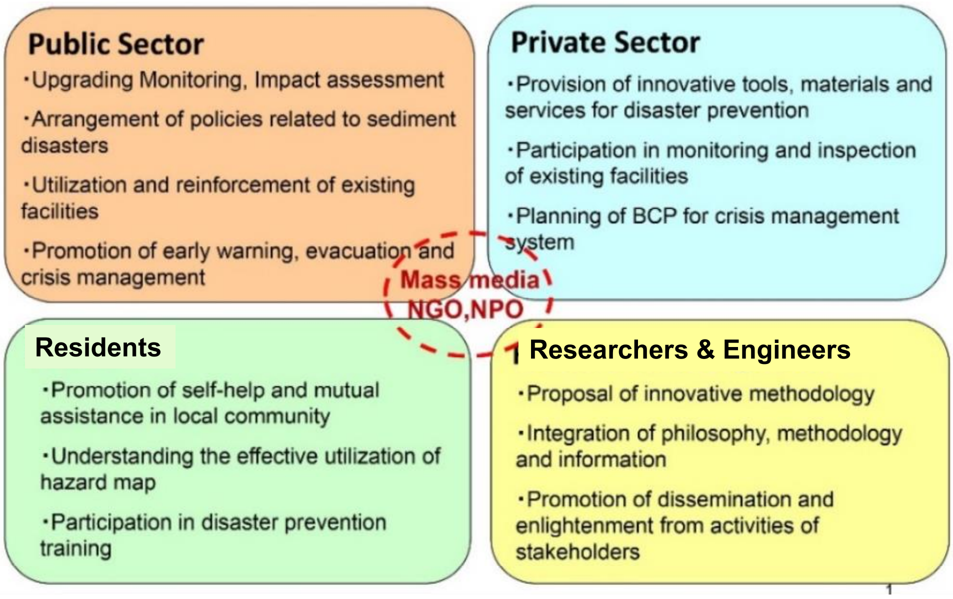
Climate Change Responses and Their Synergies



Dual Approach of Adaptation: Top-down and Bottom-up Approaches



Roles of Stakeholders



Roles of Private Sector (PS) in SDGs Including Climate Change Responses
【民間企業の役割／責任】

◆ Demonstrate how private sector entities are prepared to respond to SDGs including climate change.

◆ Demonstrate how their own techniques and skills enable contributions to SDGs

◆ Disclose issues related to climate change associated risks and opportunities in accordance with proposals by the Task Force on Climate-related Financial Disclosures (TCFD)(2017) (https://adaptation platform.nies.go.jp/private_sector/tcfd/index.html)

LRRI Technologies for Infrastructural Sustainability

[Part 1] Techniques for Infrastructural Sustainability
（インフラ長寿命化技術）

Tools for Reducing Effects of Extreme Events

Hardware
- Strengthening resilience of infrastructure
- Development of IoT, ICT, and DX
- Monitoring tools
- Temporary and permanent recovery techniques

Software
- Hazard prediction
- Easily usable hazard maps
- Evacuation support systems

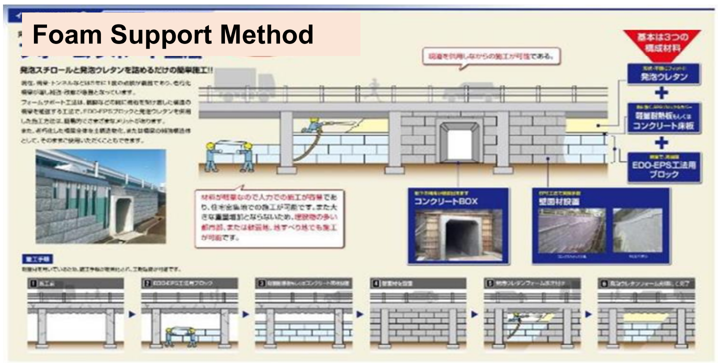
NPOs, NGOs, etc.

Human-ware
- Community-based adaptation
- Self help and mutual help
- Educational support and enlightenment for awareness building

Command-ware
- Public help
- Transmission of information for safe and effective evacuation
- Enlightenment for awareness building for local residents
- NPOs, NGOs, etc.

12

Techniques for Increasing Resilience against Infrastructural Aging and Earthquakes
（橋梁の長寿命化）



(1) Smoothly workable

○供用しながら施工可
○騒音が少ない
○ヤードが小さい

(2) Environmentally friendly

○軟弱地盤に適用
○埋設管の負荷軽減
○住宅密集地に採用可

(3) Economical

○高さによるが撤去・
架け換えより安価

Filling EPS and urethane into spaces between bridge piers

(Developed by JSP Co. Ltd. in cooperation with Achilles Corporation, Okasanlivic Co. Ltd., and Showa Concrete Industry Co. Ltd.)

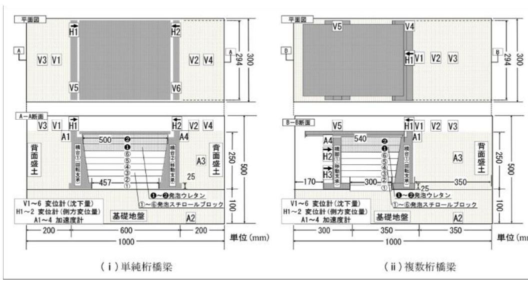
Effects of Foamed Geosynthetics (Geofoam) against Ageing of Bridges

[Testing condition]

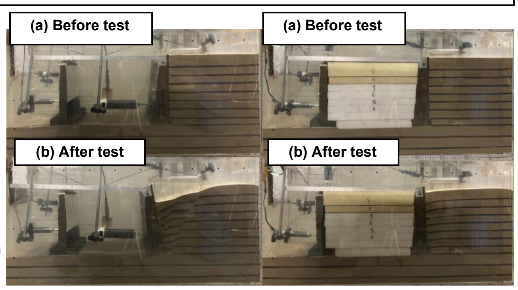
(□) Input acceleration: 200 cm/s^2
(□) Frequency: 4 Hz
(□) No. of cycles: 30 (sinusoidal)

[Test results]

(1) Combining EPS with urethane is effective for reducing earthquake damage.
(2) FCB and flowable concrete are also available as a technique for increasing anti-earthquake capabilities.



Outline of laboratory model tests
(simulating Level 1 earthquake)



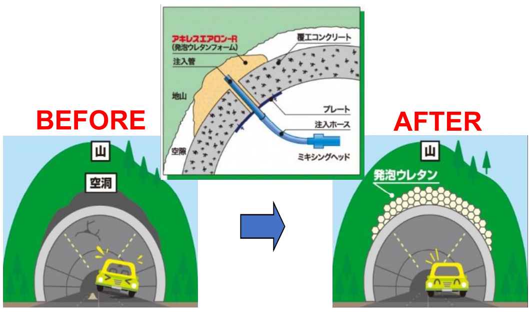
(a) Without RF (b) With RF
(EPS with urethane)

Example of shaking table tests using Foam Support Method (FSM)

Infrastructural Rehabilitation Using Geofoam
Tunnel backfill void repaired using urethane injection "Tn-p Method"

Least destructive and environmentally safest tunnel repair method (Achilles Corp.)

◆ **Features**
- Only compact foam injection equipment is required.
- Urethane foam is light but also durable and supportive.
- Backfill foam can be cured in a wet environment, even with standing water.



Item	Unit	SK-01	SK-02	SK-03	SK-04	SK-05	SK-06
Foam density	kg/m^3	40±4	30±3	100±20	60±9	150±30	175±30
Compressive strength	N/mm^2	≥0.2	≥0.14	≥0.9	≥0.45	≥1.0	≥1.5

Quantitative Risk Analysis (QRA) for Major-Risk Plants

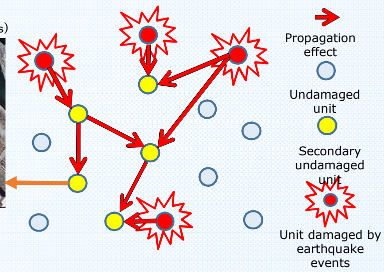
(After H.N. Phan, et al., J. of Loss Prevention in the Process Industries, Vol. 53, May 2018, pp. 136-148)

Industrial plants ⇔ Earthquakes

NATECH events (Natural Hazard Triggering Technological Disasters)

Probit function for the damage caused by physical effects

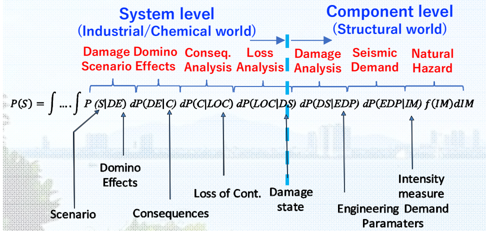
A Novel Framework for QRA under NATECH events



→ **Multiple accidental chains** are adopted considering the propagation effects due the loss of containment (LOC)

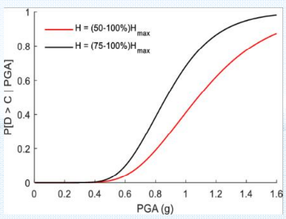
→ **Damage chains and propagate damage** are **automatically generated** based on Monte Carlo Simulations

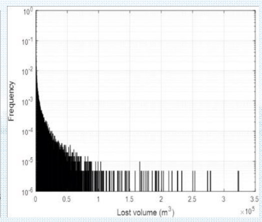
Annual probability of risk due to loss of volume



P(X|Y) is the conditional probability of X given Y.

Machine learning-based **Parametric Fragility Curves**





PEDI Civil Solutions (https://pedicivil.com/)
Contact Person: nam.phan@pedicivil.com (Mr.Nam Phan)

LRRI Technologies for Infrastructural Sustainability

[Part 2] Climate Sustainability

Technologies for Climate Sustainability （気候持続性技術）

◆ Mitigation Techniques（緩和技術）
◆ Adaptation Techniques（適応技術）: Hard, Soft and Human Measures

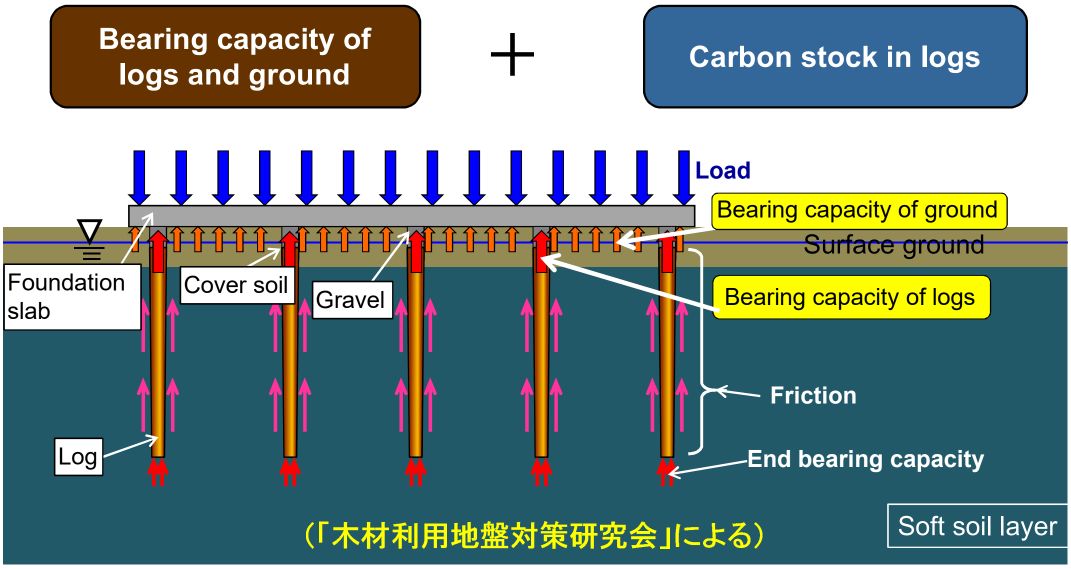
In addition,（加えて）

◆ Synergetic Techniques（融合技術）
◆ Multiple Purpose Techniques（多目的技術）

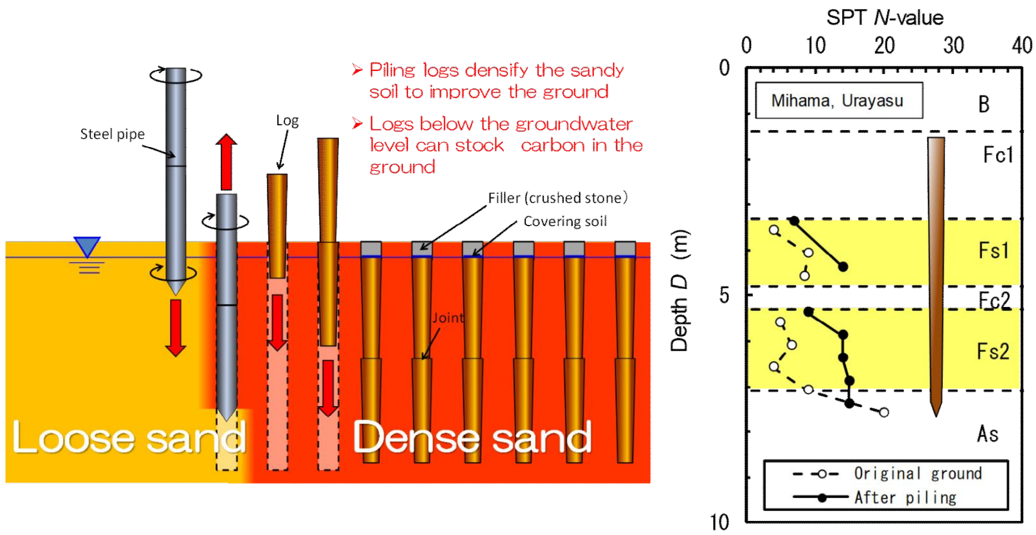
Aim at proposal of unprecedented techniques with newly added value

Log Piling Method for Soft Ground and Carbon Stock
（丸太打設軟弱地盤対策＆カーボンストック工法）

●日本建築センター (BCJ評定-FD0577-02)



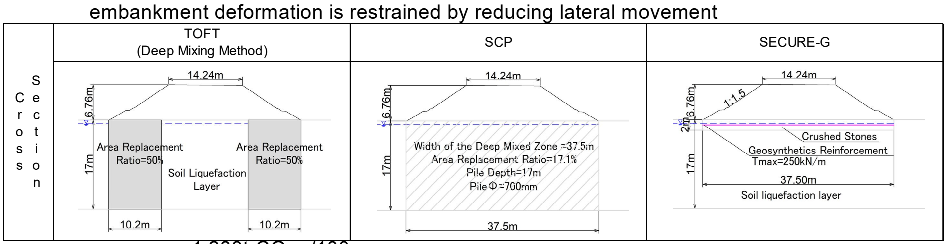
Log Piling Method for Soft Ground and Carbon Stock
（丸太打設軟弱地盤対策＆カーボンストック工法）

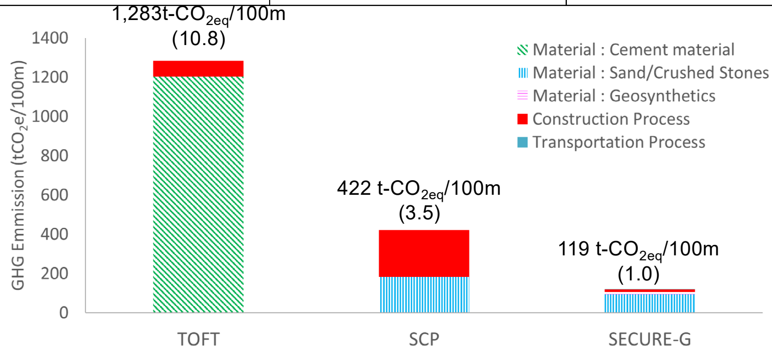


Logs are useful for both carbon storage and for reduction of liquefaction damage.

Comparison of GHG Emissions among Liquefaction Countermeasures

SECURE-G: Through geosynthetics reinforcement and gravel stiffness, embankment deformation is restrained by reducing lateral movement





GHG emissions from geosynthetics reinforcement are retrieved from EPD

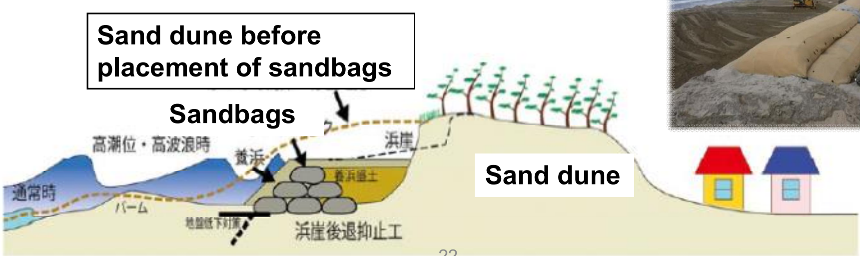
(From Eternal Preserve Co. Ltd., エターナルプレザーブ㈱)

Sandbag (Geo-tube) for Beach Cliff Erosion

Countermeasures against SLR and intensified Typhoon waves

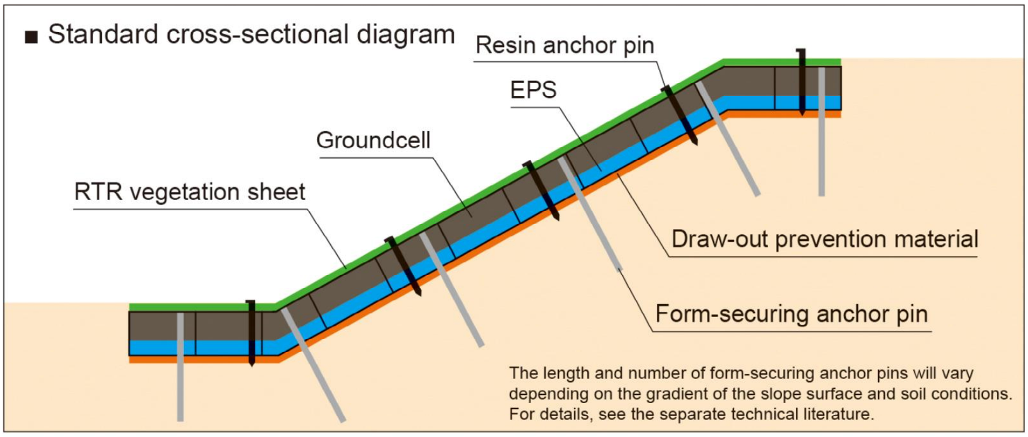
Sandbags reduce beach cliff and sand dune degradation caused by coastal erosion together with reinforcement of a dyke. Moreover, they can mitigate salt damage and flying sand at coastal areas.

In contrast to concrete walls, construction work is swift. The sandbags also maintain the landscape because they are embedded in the dyke.



(From Mitsui Chemicals Industrial Products Ltd.　三井化学産資㈱)

Slope Surface Protection against Torrential Rains and Global Warming



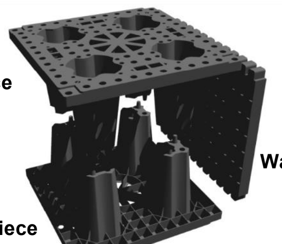
This earth reinforcement technology is characterized by the combination of geocells (called “Groundcells”) with vegetation against surface erosion and erosion caused by torrential rainfall. This technique is also available for heat protection through EPS.

(RTR ® Method owned by Tokyo Printing Ink Mfg. Co. Ltd.（東京インキ㈱）

Rainwater Storage Tank
（多目的技術）

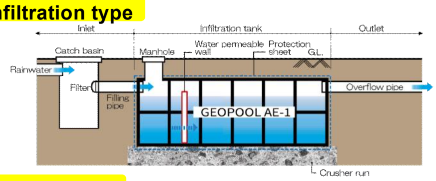
Geopool AE-1 is a rainwater infiltration and storage tank used as a countermeasure against floods during torrential rains. Because it is molded with eco-friendly recycled plastic, it is lightweight and easy to handle. It can reduce costs and can shorten construction periods compared to conventional concrete tanks.

Flood measures and rainwater storage
► multi-purpose and multi-function

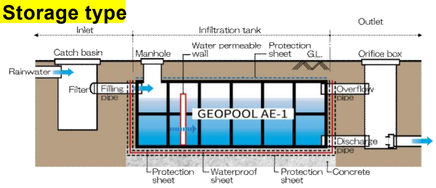


(Geopool AE-1; Okasanlivic Co., Ltd.)

(a) Infiltration type



(b) Storage type



Technique for River Basin Disaster Resilience and Sustainability by All (Flood Disaster Countermeasures: Emergency Roadway on Sludge using D･Box)
（多目的技術）

(1) **D•Box** method involves filling PP bags with crushed stone and other materials for improvement of soft ground without cement. This approach reduces vibration and CO_2. Moreover, it minimizes liquefaction damage while maintaining high permeability and environmental benefits.

(2) **Floods** and **Tsunami waves** engender the deposition of sludge and debris, blocking the passage of emergency and construction vehicles. By placing **D･Box** on top of this sediment during such disasters, an emergency roadway can be established rapidly, ensuring quick and direct relief routes.

(3) **D･Box installations** are filled with materials such as sludge and concrete rubble. The surface is layered with steel plates or planks to allow vehicles to pass.

Example of sedimented sludge resulting from an embankment breach

Although crushed stone (C40) is preferred as the infill material, on-site natural soil or concrete rubble (φ300 mm or smaller) can also be accommodated.


Lifting of the D-Box (1.5 m × 1.5 m × 0.45 m).


Installation of D-Box the sludge


Installation of D-Box on the sludge

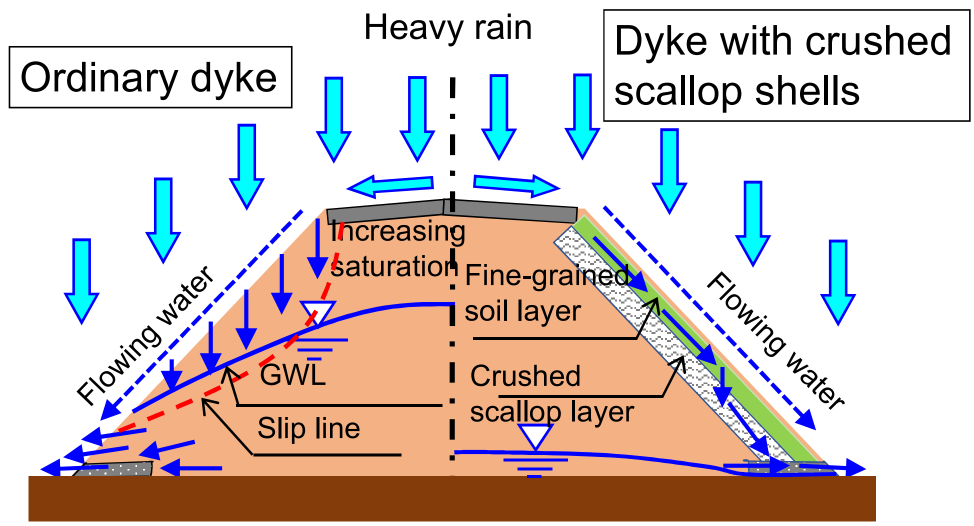

Internal structure of the D-Box (can be lifted from a single point using truss bands)


Scaffolding boards used for mitigation (Indonesia)

Disaster damage reduction and environmental impact reduction ► multi-functional

(From Metry Technical Research Institute Co., Ltd.), メトリー技術研究所㈱による)

Technique for River Basin Disaster Resilience and Sustainability by All
（流域治水技術）



Crushed scallops might be capable of greenhouse gas (CO_2) capture.
(From Professor Kaoru Kobayashi, Ibaraki University, Japan)

Substructure Foundation Scour Monitoring System
（ソフト技術）

[Technical overview]

This technology remotely monitors scouring statuses of bridge pier foundations in rivers, enabling data measurement and confirmation of soundness without visiting the site.
This system determines whether a bridge is passable or not during a flood and notifies the administrator by e-mail when an abnormality occurs.

[Features]

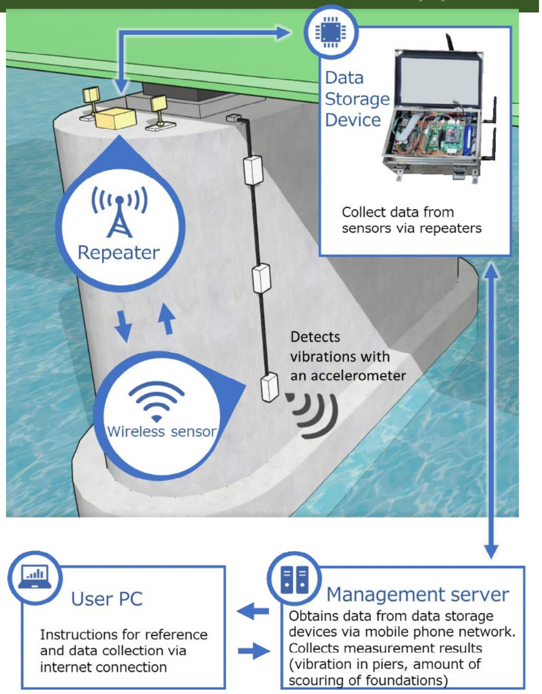
- Requires only on-site installation.
- Installation costs can be reduced depending on the accuracy of detection of changes caused by scouring.
- Thresholds for issuing alerts can be set arbitrarily.

[Effect]

- Rapid monitoring of scouring status through constant monitoring
- Ensures safety without being close to substructures, even during floods
- Supports initial response in the event of a disaster through notification of abnormalities by email

[Performance]

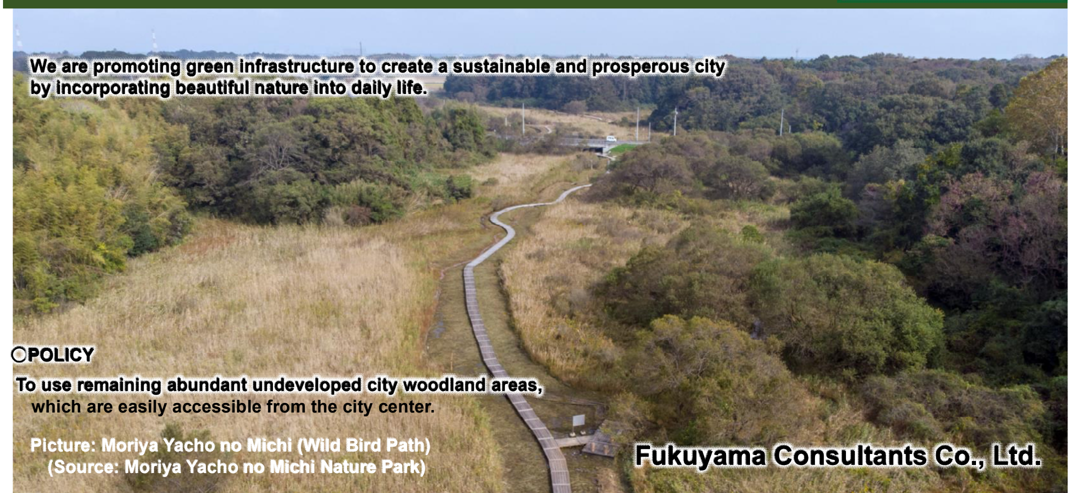
In Japan, we have track records of data from two nationally managed bridges and three prefecturally managed bridges. We have more than 30 spot measurement records for road bridges and railway bridges.



Contact Information	Fukuyama Consultants Co., Ltd. https://www.fukuyamaconsul.co.jp/ m.miyamura@fukuyamaconsul.co.jp (charge: Miyamura)

Strategic Green Infrastructure Promotion Project through Public--Private Partnership in Moriya City, Ibaraki Prefecture
-- Moriya Green Infrastructure Initiative --
適応技術例　（ソフト技術）

MORIYA GREEN INFRASTRUCTURE PROJECT
もりやグリーンインフラプロジェクト



- The Moriya Green Infrastructure initiative began in November 2017 when Moriya City and Fukuyama Consultants signed a comprehensive public-private partnership agreement.
- The project is led by the Moriya Green Infrastructure Promotion Council, a public--private consortium comprising the city and the private sector. The goal is to launch a series of projects based on the policy of green infrastructure in the city through public--private partnership.

Future Outlook for Climate Change and SDGs in LRRI （将来展望）

◆ Proposal of **multi-purpose and multi-functional technologies** through **synergies** among different fields, industries, and organizations with different standpoints such as

（融合による多目的で多機能な新しい技術）

► **Different fields**（異なる**分野**）: Civil engineering, weather information and ICT

► **Different industries**（異なる**業種**）: Construction industries, material industries and energy industries

► **Different organizations**（異なる**組織**）: Local governments, research institutes, private sector entities, non-profit organizations, and residents

◆ Play roles in **local resilience strengthening** through **synergetic actions** **（自助，共助，公助推進サポート）** on climate change response measures from Japan and overseas

➢地域強靭化

Summary

◆ How Should We at LRRI Cope with Climate Hazards? （LRRIは気候ハザードのどう立ち向かうか？）

► (1) Proposal of interdisciplinary responsive measures using synergetic approaches

► (2) Increasing technical capabilities through educational support for mutual enlightenment

◆ LRRI Technologies and Strategies for Climate Change Responses （気候変動対応のためのLRRI関連技術&戦略）

► Proposal of multi-purposed and multi-functional technical development

◆ Future Prospects for Climate Change and SDGs in LRRI （気候変動とSDGs対応の将来展望）

► (1) Sharing the roles and responsibilities of construction fields

► (2) Contribution to enhancement of local resilience