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Level of Long-term Stabilization of Global Warming and Climate Change Risks

Comprehensive assessment of climate change impacts to determine the dangerous level of global warming and to determine appropriate stabilization target of atmospheric GHG concentration

Coastal hazards induced by climate change: an assessment of impacts, risks, and adaptation strategies

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S4-2(5) Project Team

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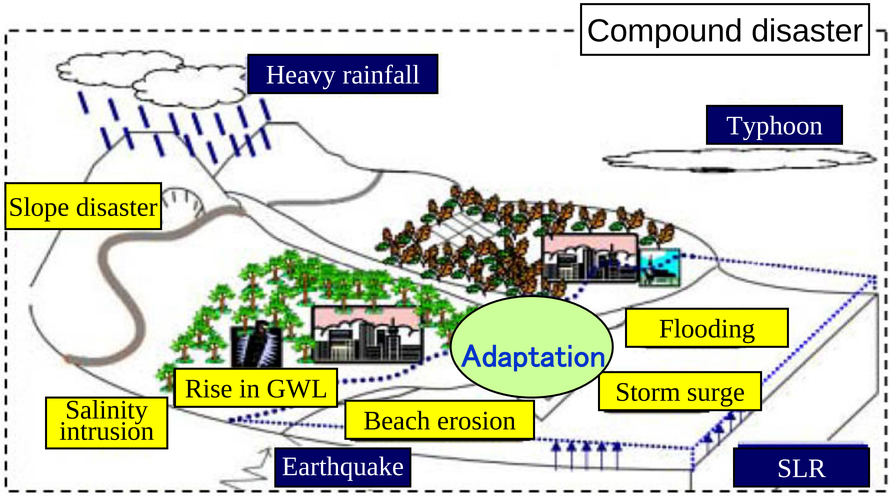
Outline

- Introduction
- The coastal hazards induced by climate change
  - Physical & economic impacts
  - Storm surge in coastal area
  - River flooding
  - Liquefaction
  - Slope disaster
- Perspectives
  - Adaptation
  - Conclusion

Introduction

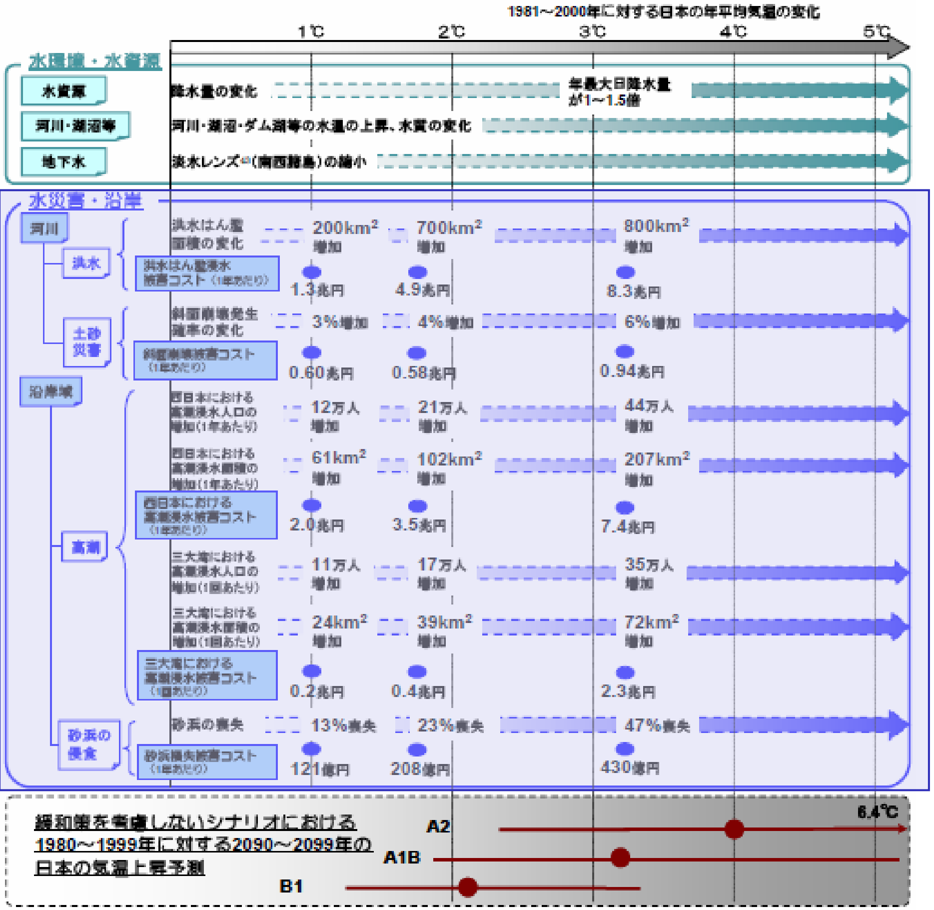
Introduction

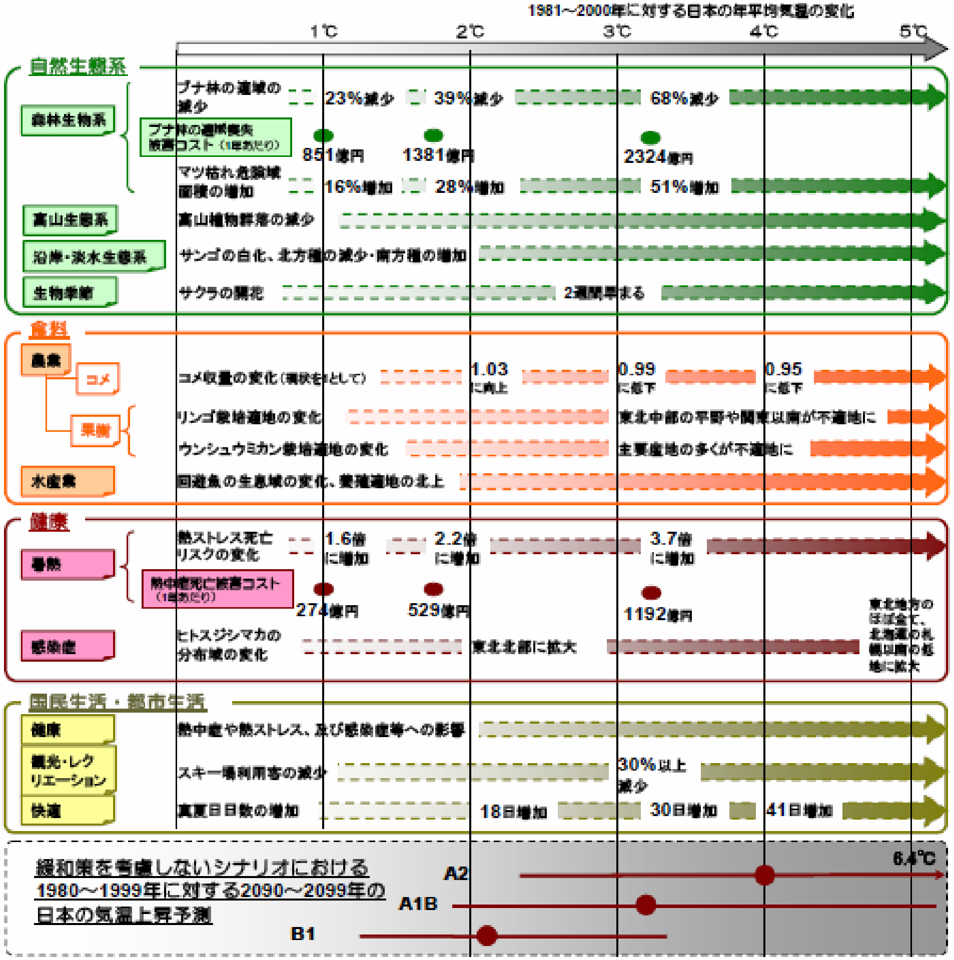
- Evaluate the impact on coastal area due to climate change in Japan
  - Compound disaster
    - Natural hazards combined with climate change
  - Storm surge, river flooding, liquefaction, slope disaster
- Assess the economic damage
  - Stock (assets) or flow (productivity) of the economy
- Cost-benefit analysis of impacts and adaptation is not considered YET
  - Next research target



Climate impacts in Japan

- c.f., IPCC(2007)



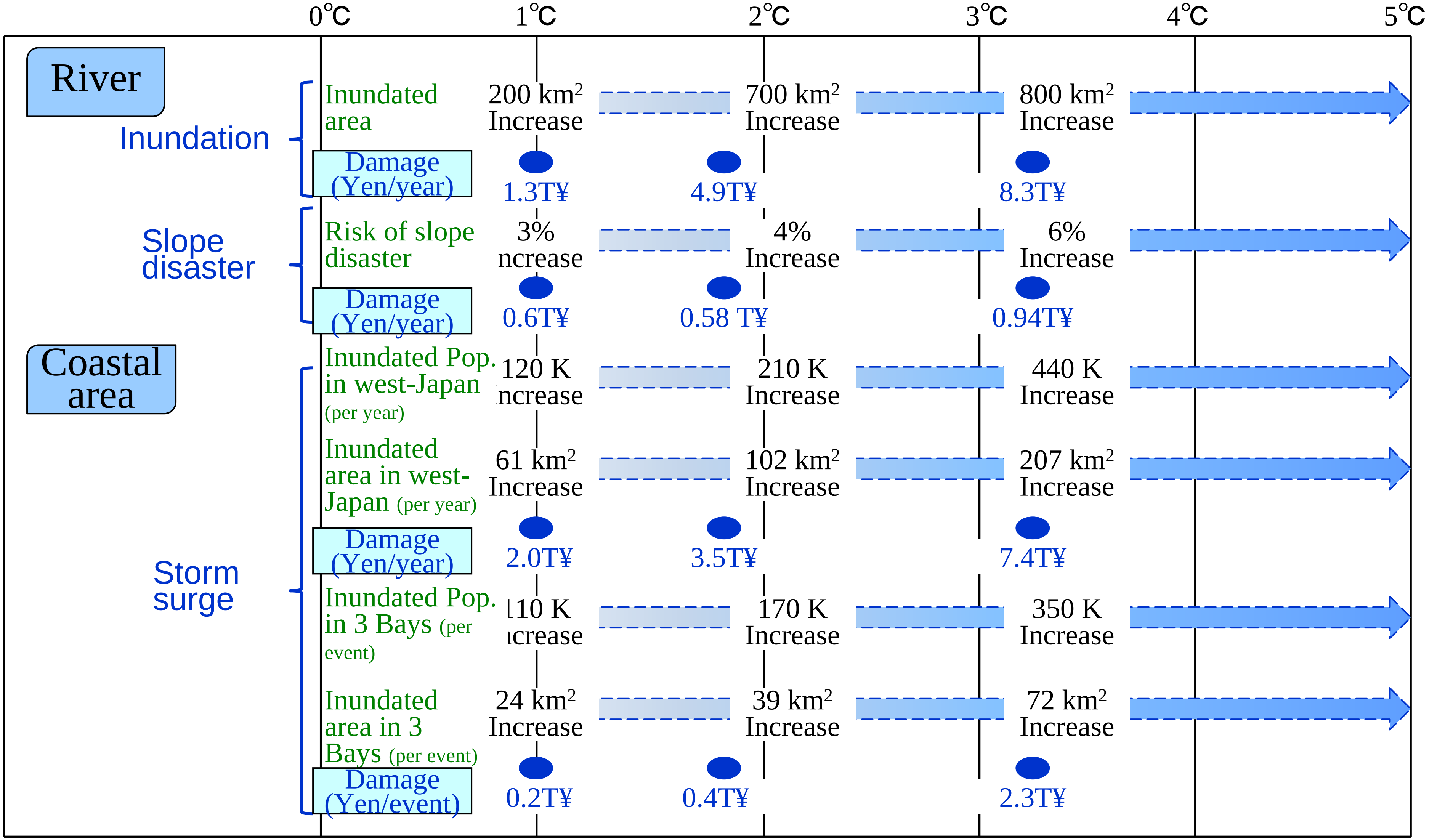


Source: JMA /MEXT/MOE (2009) “Climate change and the impact in Japan”
Based on Comprehensive Impact Assessment Team(2009)

Impacts on coastal areas

- MIROC: SRESA1B scenario
- GDP in Japan (2008): 556[T¥-real]

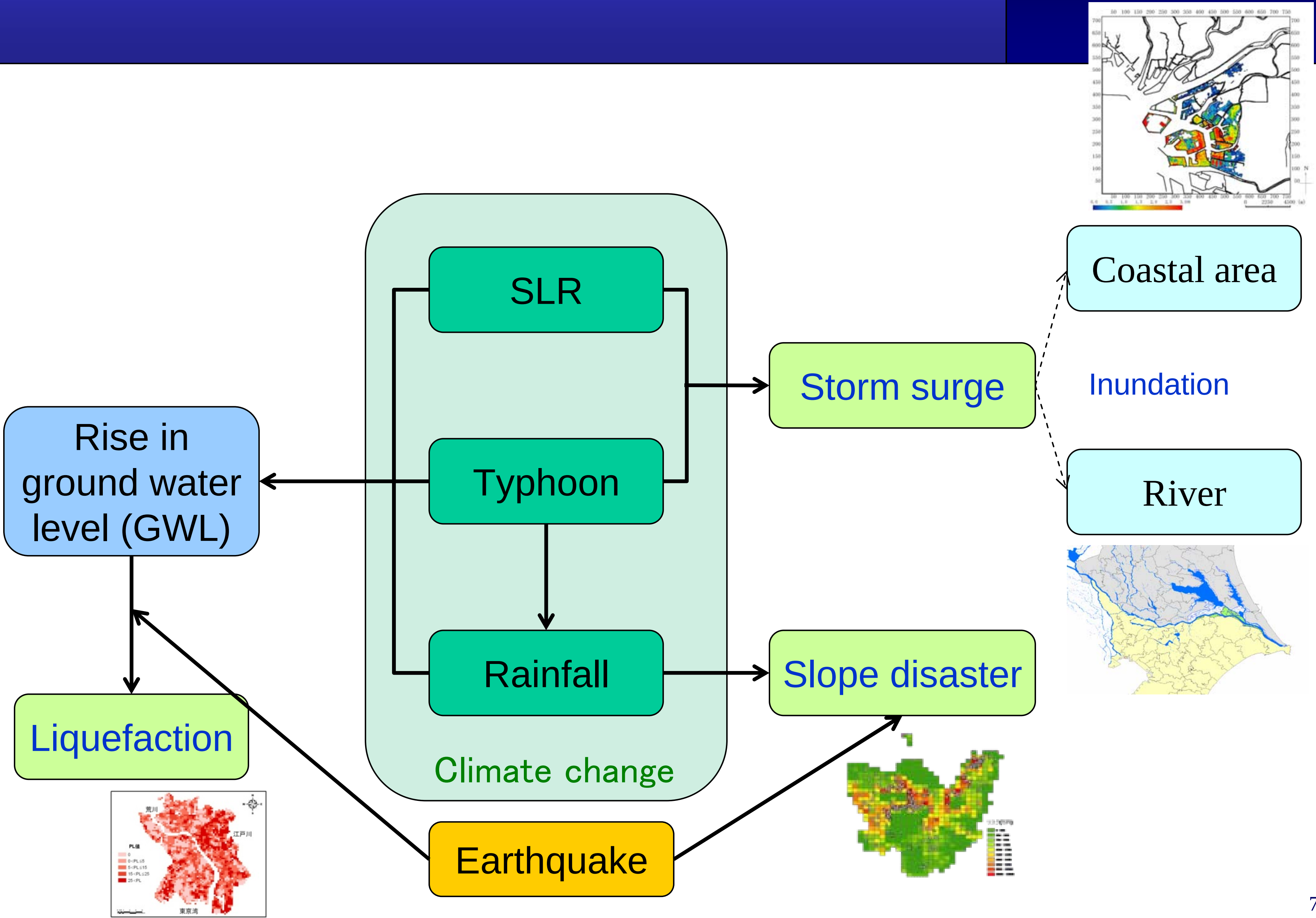
Mean annual temperature change relative to 1981-2000



River	Inundation	Inundated area	200 km² Increase	700 km² Increase	800 km² Increase
		Damage (Yen/year)	1.3T¥	4.9T¥	8.3T¥
	Slope disaster	Risk of slope disaster	3% ncrease	4% Increase	6% Increase
		Damage (Yen/year)	0.6T¥	0.58 T¥	0.94T¥
Coastal area	Storm surge	Inundated Pop. in west-Japan (per year)	120 K ncrease	210 K Increase	440 K Increase
		Inundated area in west-Japan (per year)	61 km² Increase	102 km² Increase	207 km² Increase
		Damage (Yen/year)	2.0T¥	3.5T¥	7.4T¥
		Inundated Pop. in 3 Bays (per event)	110 K ncrease	170 K Increase	350 K Increase
		Inundated area in 3 Bays (per event)	24 km² Increase	39 km² Increase	72 km² Increase
		Damage (Yen/event)	0.2T¥	0.4T¥	2.3T¥

Based on Comprehensive Impact Assessment Team(2009)

External forces and hazards



Climate change

SLR

Typhoon

Rainfall

Storm surge

Inundation

Coastal area

River

Slope disaster

Rise in ground water level (GWL)

Liquefaction

Earthquake

Differences in each research

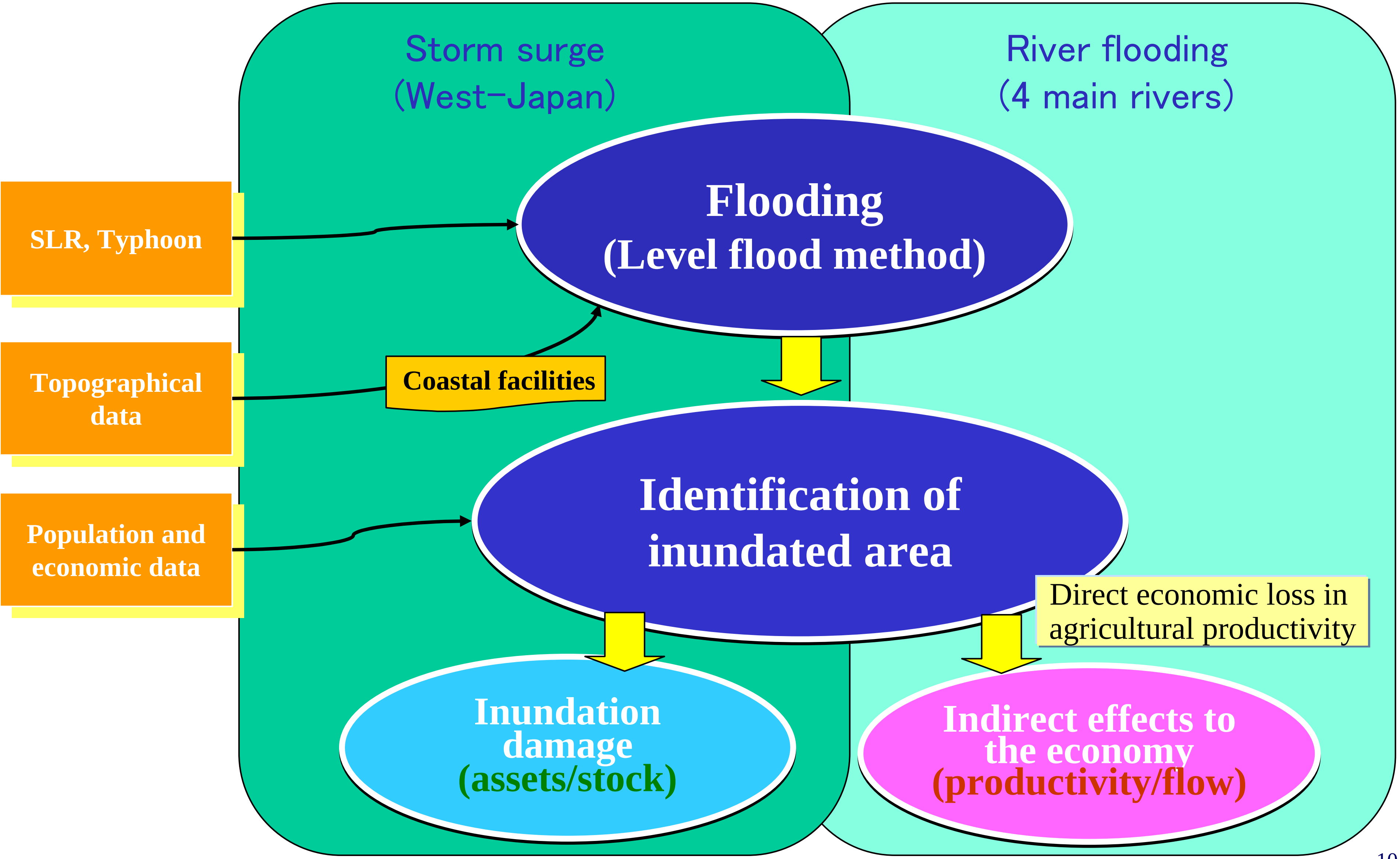
Table Researches in S4-2(5) project

	Storm surge	River flooding	Liquefaction	Slope disaster
Area	Coastal area in 3 major bays, West-Japan	Tone, Shinano, Yoshino, Chikugo river	Tokyo Bay area, Ishikari plain (Hokkaido)	Kyushu
Period	2000-2100	2100	1990-2100	2000-2100
External forces	SLR:0～100cm, storm surge: 0-1.6	SLR:59cm+storm surge + tide level	1)SLR:88cm 2)SLR:88cm+Rainfall (RCM20)	Typhoon (wind: +7.5%), Rainfall(+25%), Earthquake
Method	Level flood method, etc	Level flood method, etc	Ground model	Monte Carlo method of typhoon and damage
Economic assessment	Capital stock (assets)	Money flow (productivity)	Capital stock (assets)	Capital stock (assets)

Inundation by storm surge in coastal area

Takeshi Suzuki
National Institute for Land and Infrastructure Management (NILIM)

Method of storm surge and river flooding



Storm surge (West-Japan)

River flooding (4 main rivers)

SLR, Typhoon

Topographical data

Population and economic data

Coastal facilities

Flooding (Level flood method)

Identification of inundated area

Direct economic loss in agricultural productivity

Inundation damage (assets/stock)

Indirect effects to the economy (productivity/flow)

Inundation by storm surge in coastal area (West-Japan)

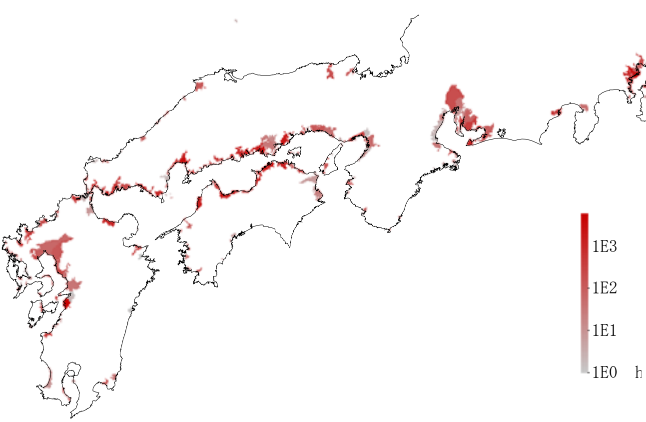


Fig. Inundated area
SLR: 60cm, Storm surge: 1.3

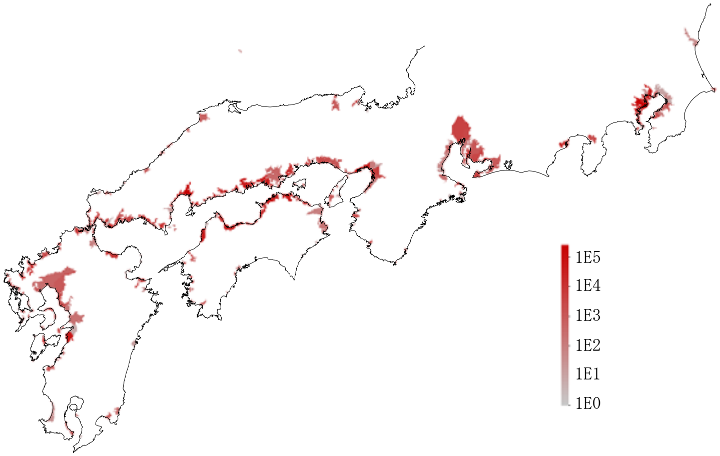


Fig. Inundated population
SLR: 60cm, Storm surge: 1.3

- More vulnerable in enclosed area such as Inland sea and inlets
  - Lack of protection facilities, e.g., dikes

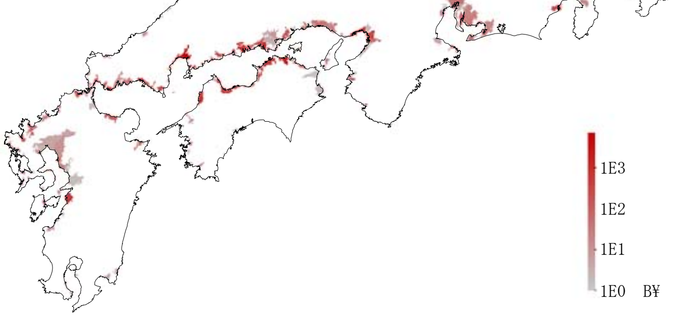
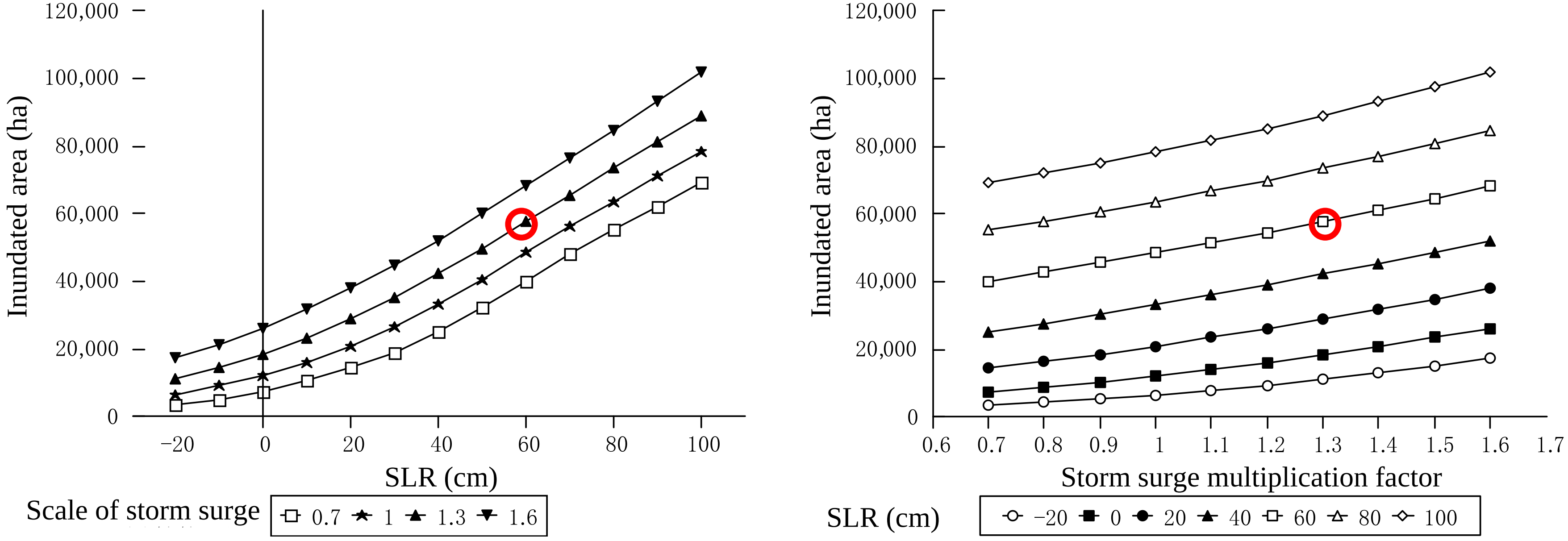


Fig. Inundation damage
SLR: 60cm, Storm surge: 1.3

Inundated area of storm surge in coastal area (West-Japan)

- Relationship between impacts and hazard

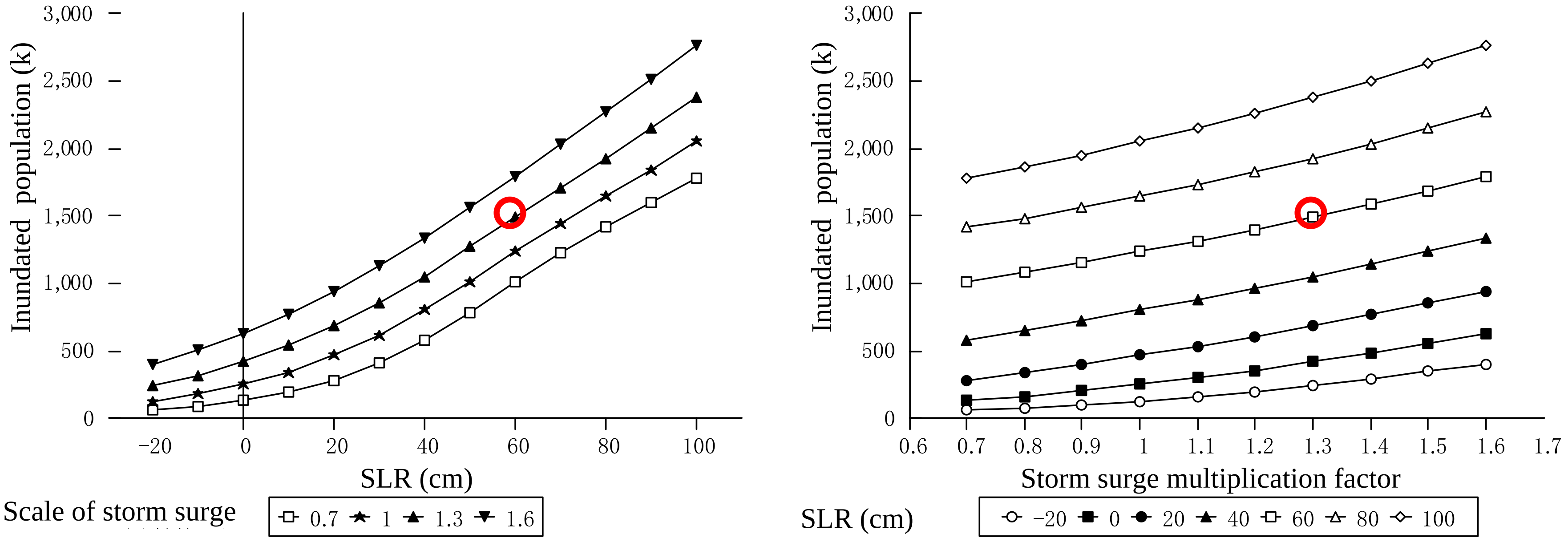


(a) SLR

(b) Scale of storm surge

Sensitive to SLR!

Inundated population of storm surge in coastal area (West-Japan)

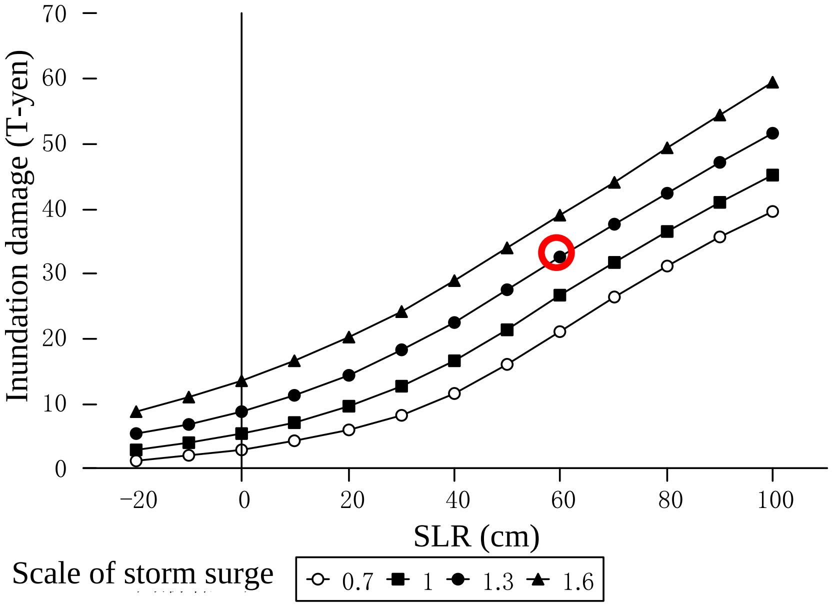


(a) SLR

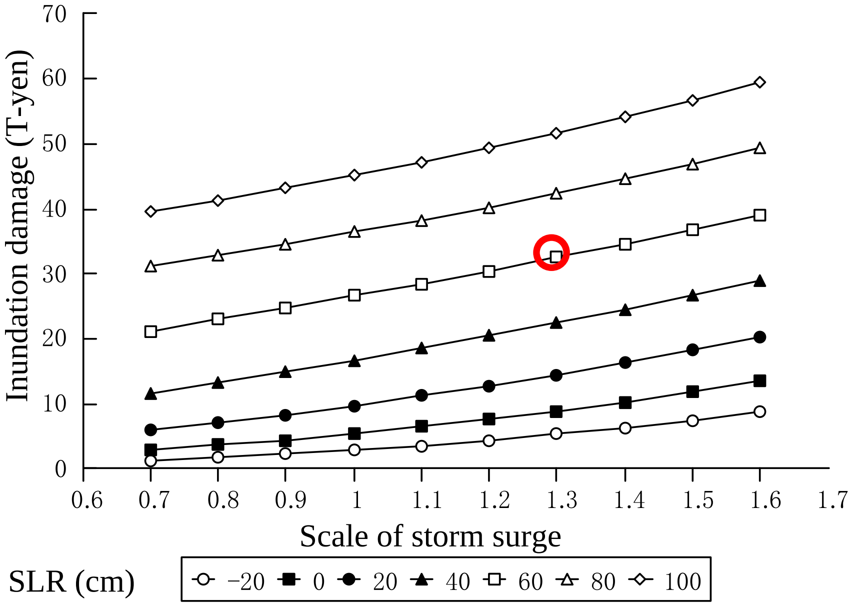
(b) Scale of storm surge

Inundation damage of storm surge in coastal area (West-Japan)

- Estimation is based on the manual of MLIT (Ministry of Land, Infrastructure, Transport and Tourism)
  - Assess the stock (property)



(a) SLR



(b) Scale of storm surge

Sensitive to SLR!

Summary: Storm surge

- This study assess the impact of inundation in coastal area due to storm surge
    - inundated area, population, and inundation damage
- The risk linearly increases as the impacts does
    - No clear threshold
- Adaptation needs as the impact increases

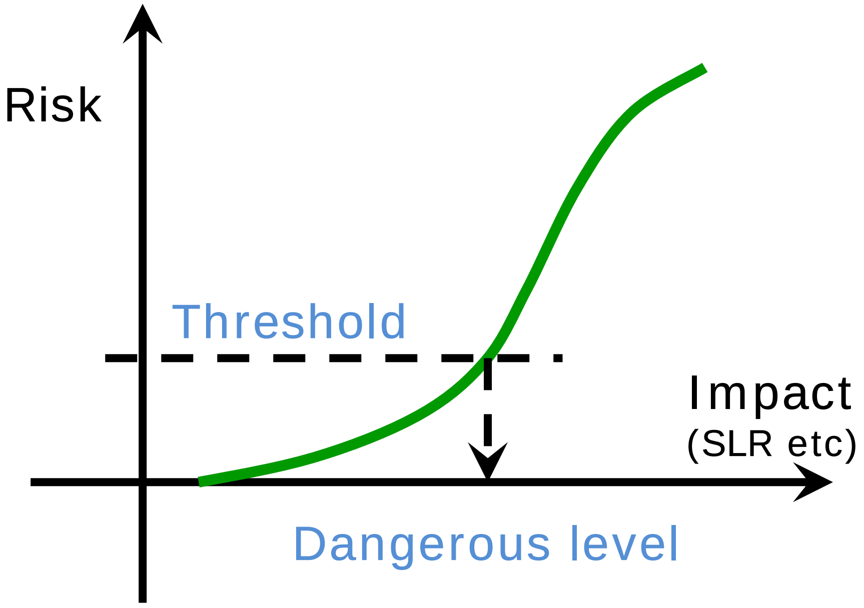


Fig. Climate-change impact function

River Flooding

Makoto Tamura, Yuji Kuwahara,
Himune Yokoki, Nobuo Mimura
Ibaraki University

Economic losses of river flooding

Input-output analysis with mixed exogenous and endogenous variables (“Mixed” I-O analysis)

- Estimate the economic losses of potential inundated area around rivers
  - Potential inundated area by Kuwahara et al. (2008)
  - Using level flood method and GIS
  - Scenario: SLR: 59cm + storm surge + tide level
- Investigated rivers

①Kuji, ②Naka, ③**Tone**, ④Ara, ⑤**Shinano**,
⑥Tenryu, ⑦Kiso, ⑧Yodo, ⑨**Yoshino**, ⑩**Chikugo**

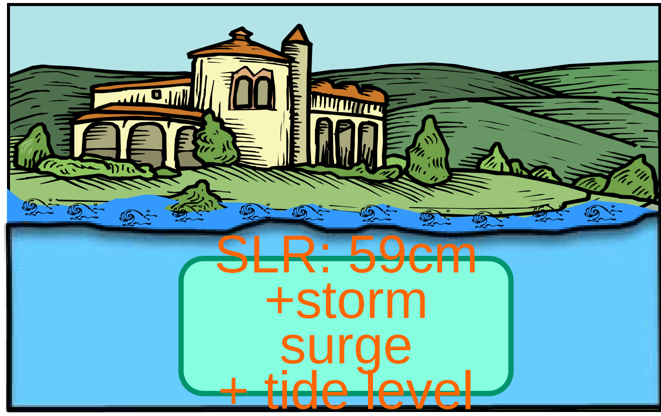


Fig. Factors of river flooding

- This study indentifies direct economic loss in **agriculture** in **the four rivers** and estimates indirect losses among industries and regions.
- Apply the “Mixed” Input-Output analysis to the economic assessment of potential inundated area
  - “Mixed” I-O analysis ⇔ Basic I-O analysis
    - c.f., Miller and Blair (1985)
  - Construct interregional I-O tables according to flooded area (i.e. flooded pref. & rest of Japan)

“Mixed” I-O analysis
Direct effect lead by flooding is considered as the change in outputs in specific industries.

- Analysis on economic productivity/flow ⇔ analysis on stock of the economy

Simulated areas and rivers

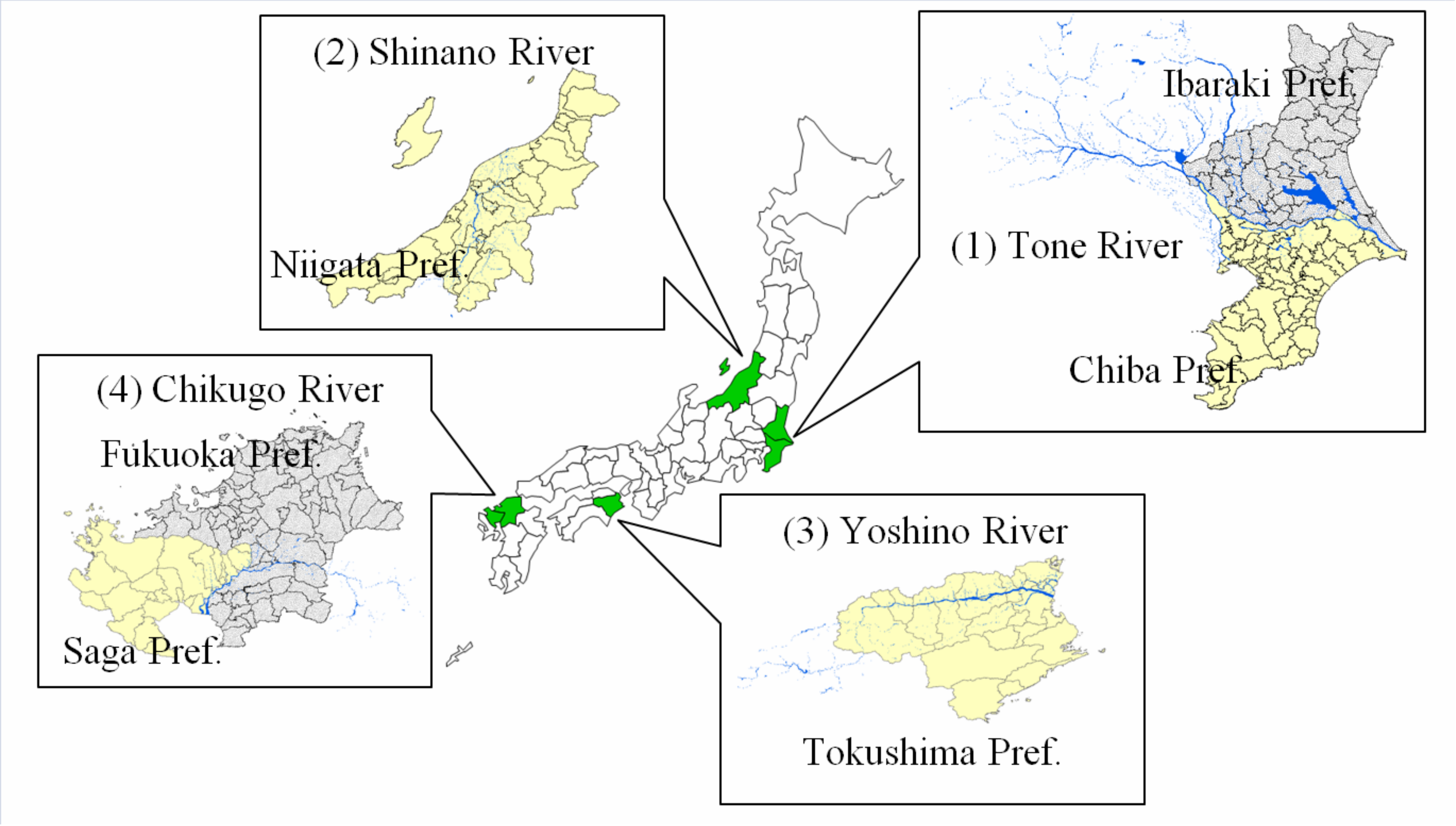
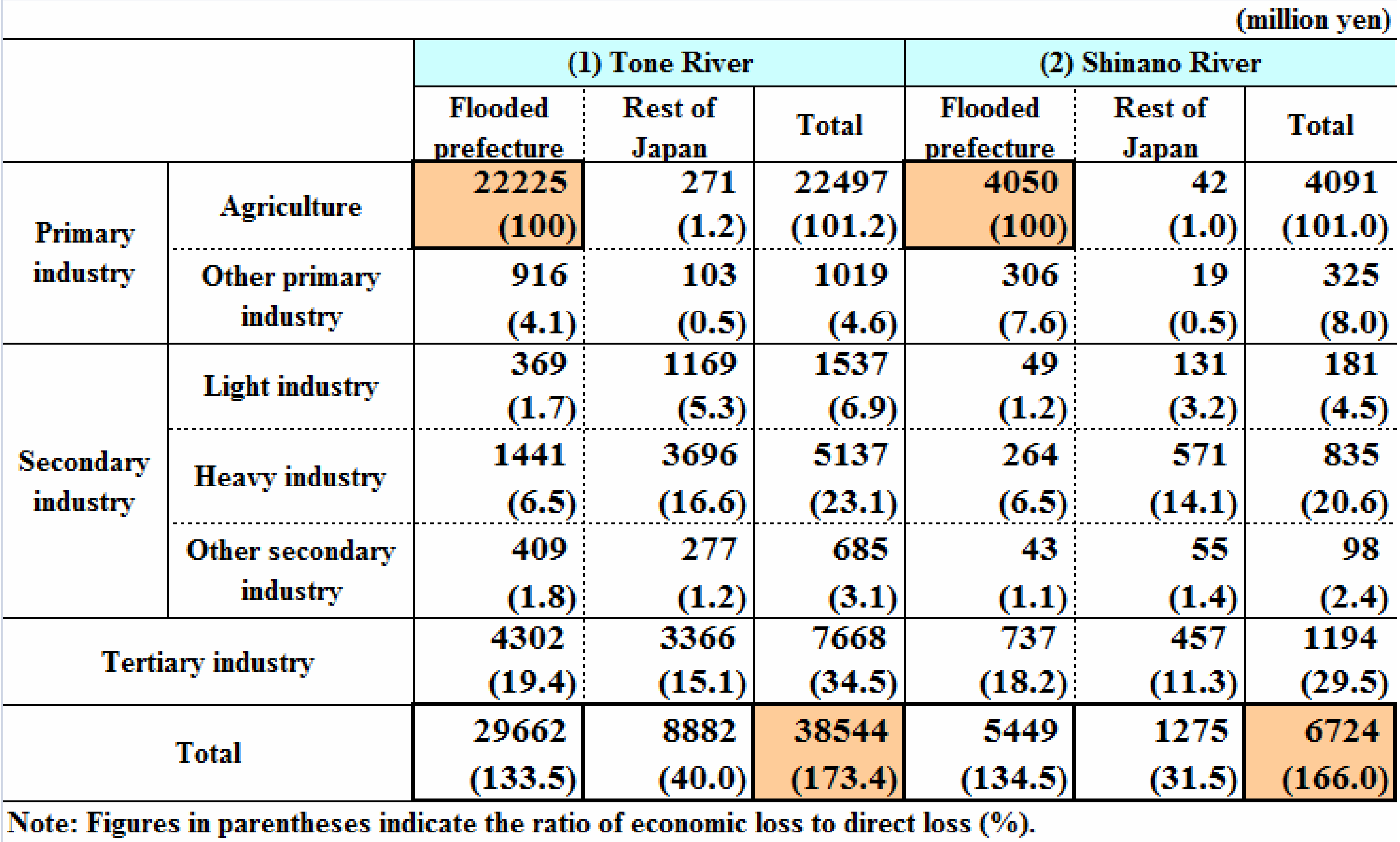


Fig. River locations and prefectures in the inundated areas

Direct and indirect losses of river flooding (part 1)



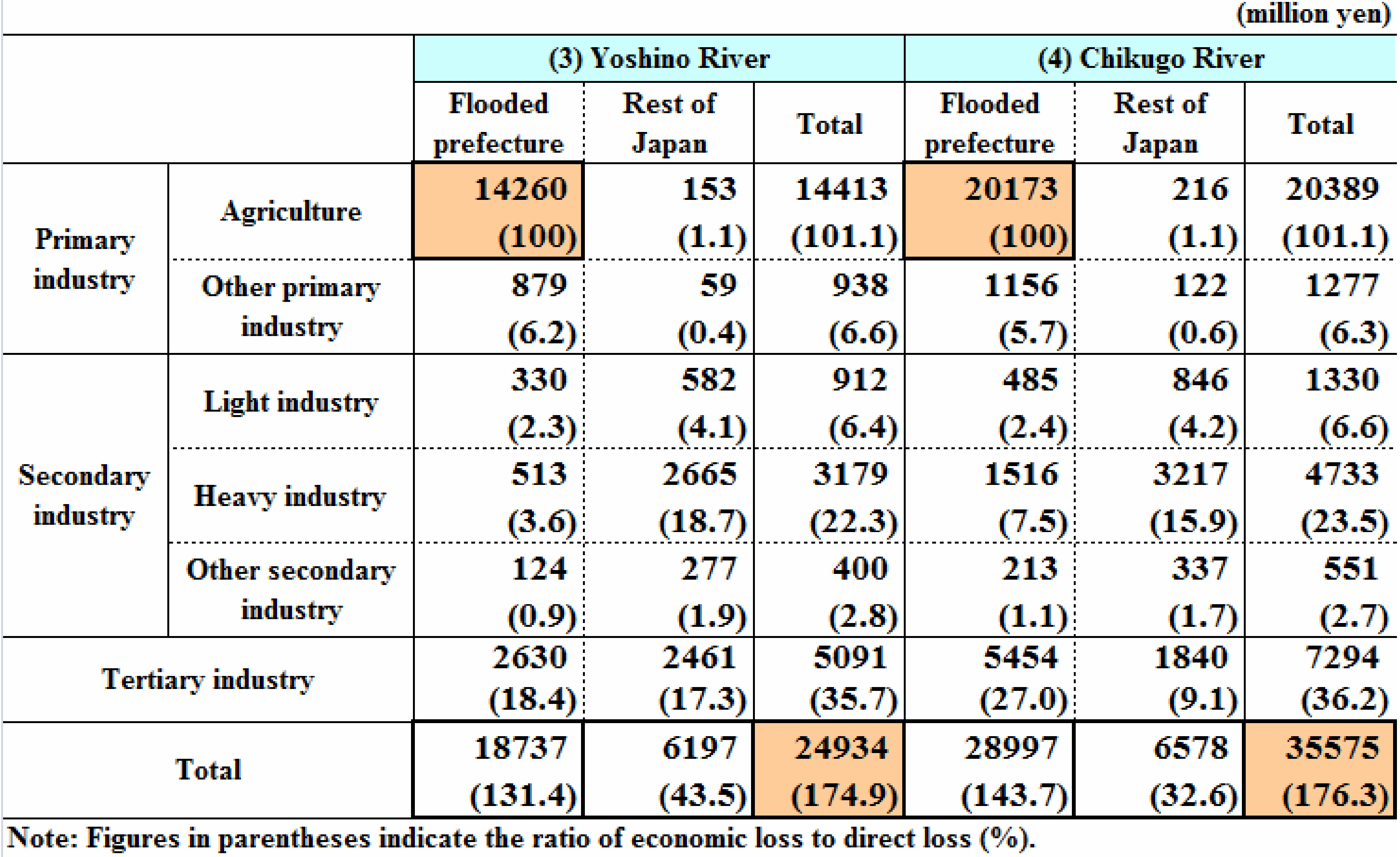
(million yen)

		(1) Tone River			(2) Shinano River		
		Flooded prefecture	Rest of Japan	Total	Flooded prefecture	Rest of Japan	Total
Primary industry	Agriculture	22225 (100)	271 (1.2)	22497 (101.2)	4050 (100)	42 (1.0)	4091 (101.0)
	Other primary industry	916 (4.1)	103 (0.5)	1019 (4.6)	306 (7.6)	19 (0.5)	325 (8.0)
Secondary industry	Light industry	369 (1.7)	1169 (5.3)	1537 (6.9)	49 (1.2)	131 (3.2)	181 (4.5)
	Heavy industry	1441 (6.5)	3696 (16.6)	5137 (23.1)	264 (6.5)	571 (14.1)	835 (20.6)
	Other secondary industry	409 (1.8)	277 (1.2)	685 (3.1)	43 (1.1)	55 (1.4)	98 (2.4)
Tertiary industry		4302 (19.4)	3366 (15.1)	7668 (34.5)	737 (18.2)	457 (11.3)	1194 (29.5)
Total		29662 (133.5)	8882 (40.0)	38544 (173.4)	5449 (134.5)	1275 (31.5)	6724 (166.0)

Note: Figures in parentheses indicate the ratio of economic loss to direct loss (%).

Table Direct and indirect losses (part 1)

Direct and indirect losses of river flooding (part 2)



(million yen)

		(3) Yoshino River			(4) Chikugo River		
		Flooded prefecture	Rest of Japan	Total	Flooded prefecture	Rest of Japan	Total
Primary industry	Agriculture	14260 (100)	153 (1.1)	14413 (101.1)	20173 (100)	216 (1.1)	20389 (101.1)
	Other primary industry	879 (6.2)	59 (0.4)	938 (6.6)	1156 (5.7)	122 (0.6)	1277 (6.3)
Secondary industry	Light industry	330 (2.3)	582 (4.1)	912 (6.4)	485 (2.4)	846 (4.2)	1330 (6.6)
	Heavy industry	513 (3.6)	2665 (18.7)	3179 (22.3)	1516 (7.5)	3217 (15.9)	4733 (23.5)
	Other secondary industry	124 (0.9)	277 (1.9)	400 (2.8)	213 (1.1)	337 (1.7)	551 (2.7)
Tertiary industry		2630 (18.4)	2461 (17.3)	5091 (35.7)	5454 (27.0)	1840 (9.1)	7294 (36.2)
Total		18737 (131.4)	6197 (43.5)	24934 (174.9)	28997 (143.7)	6578 (32.6)	35575 (176.3)

Note: Figures in parentheses indicate the ratio of economic loss to direct loss (%).

Table Direct and indirect losses (part 2)

Differences in composition of indirect losses

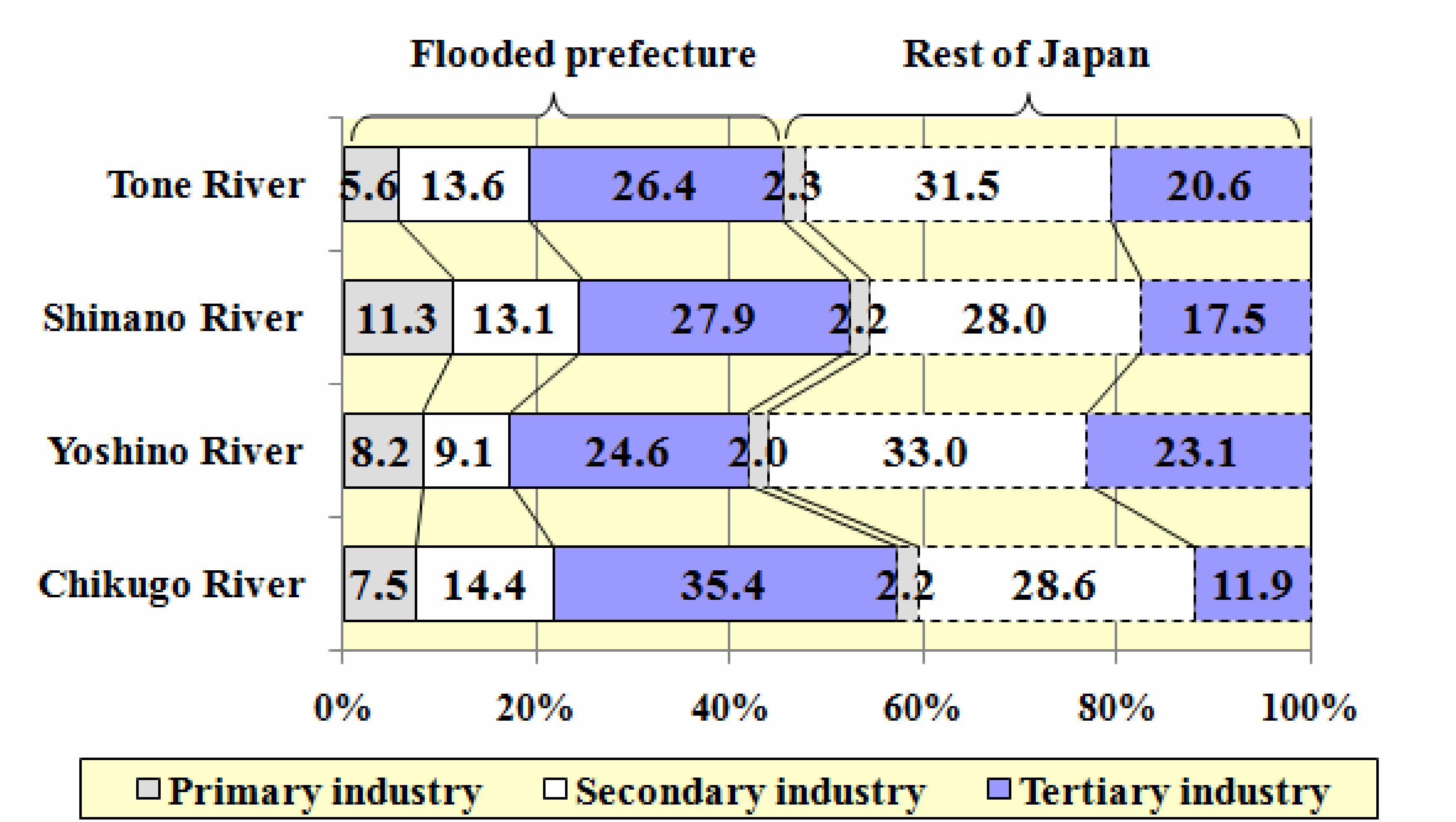
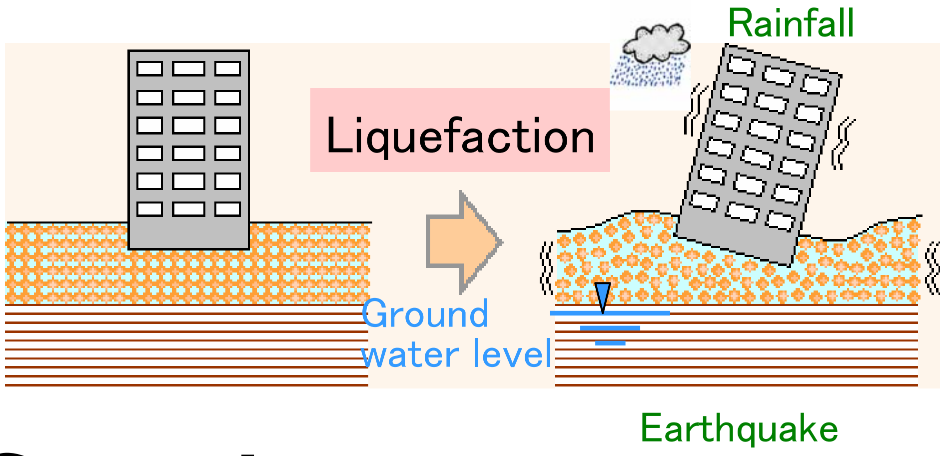


Fig. Differences in composition of indirect losses for the four rivers

Summary: River flooding

- This study examines the flow and composition of economic losses regarding the river flooding, rather than the volume.
  - Direct losses per area range from 1.01 to 2.82 million yen/ha.
  - The total losses (direct and indirect losses) are 1.66 to 1.76 times greater than direct losses.
  - The ratio of indirect losses in the outside area to total indirect losses varies from 42.7 to 58.1%.

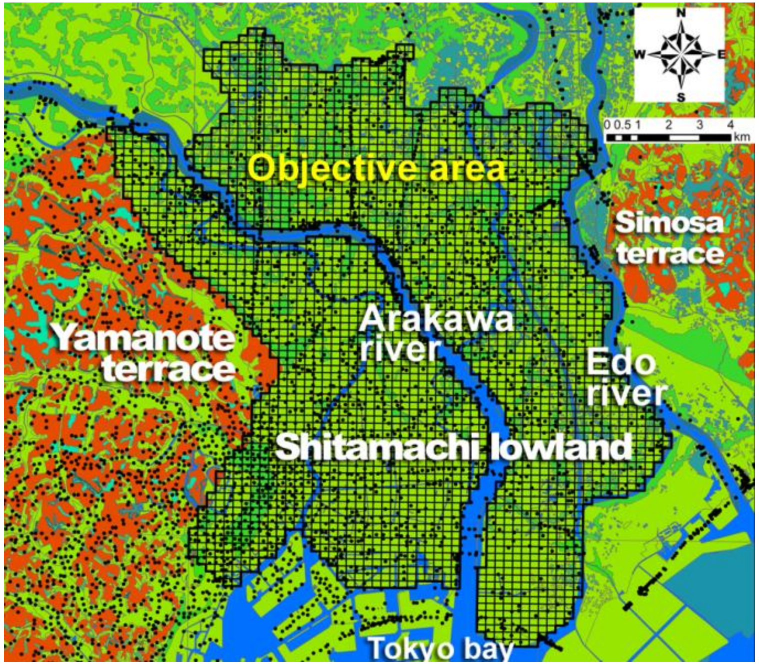
- The analyses reveal the differences of economic losses per area, and the scale of indirect losses at the river basin level.
- The results support adaptation strategies to river flooding should be implemented at the river basin level.



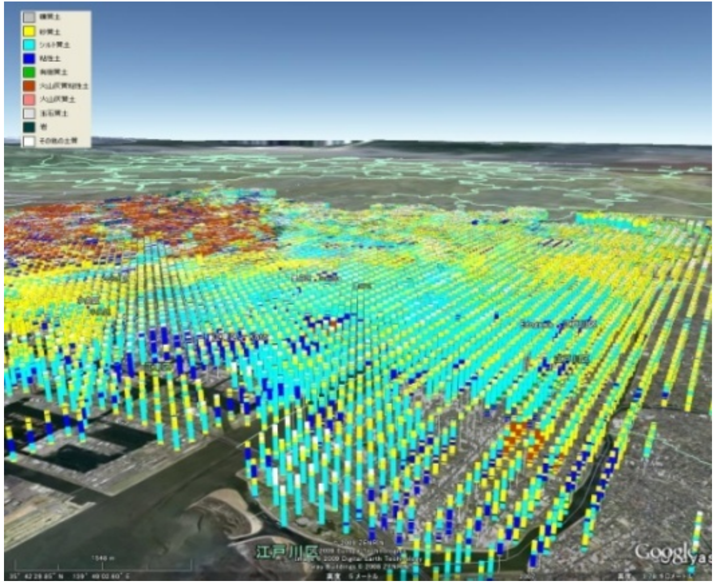
Liquefaction

Hideo Komine, Kazuya Yasuhara, Satoshi Murakami
Ibaraki University

Economic assessment of liquefaction

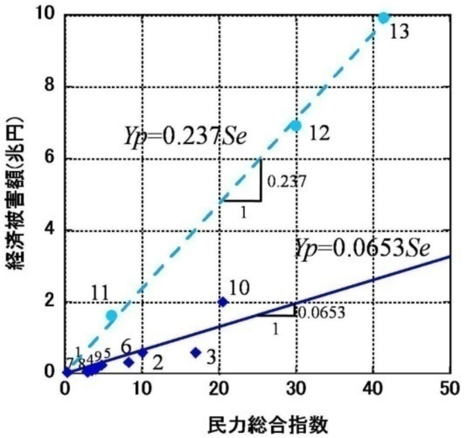


Objective area: Coastal area in the eastern part of Tokyo



- Collection of ground data
- Ground modeling (right Fig.)
- Estimation of rise in GWL due to climate change and SLR

- Hazard map of liquefaction
- Assess the economic losses
    - Assessment of stock

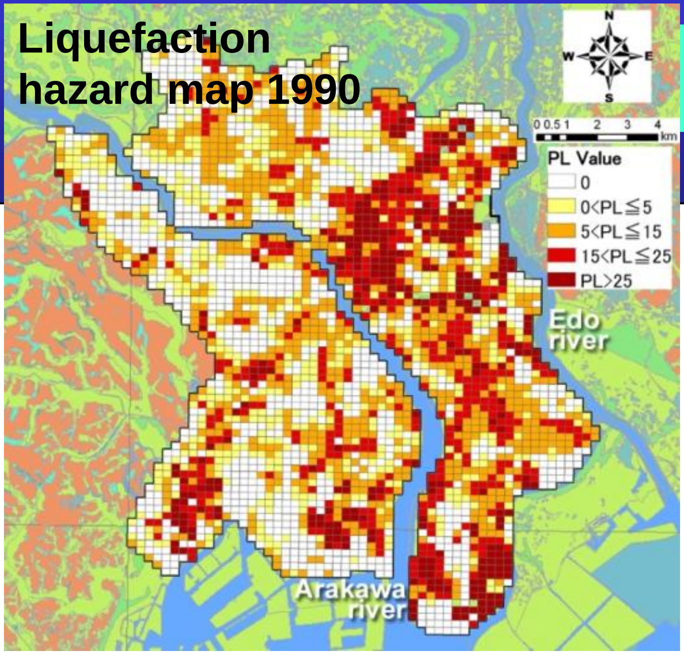


$$\boxed{Yp = 0.0653 \times H \times Se}$$

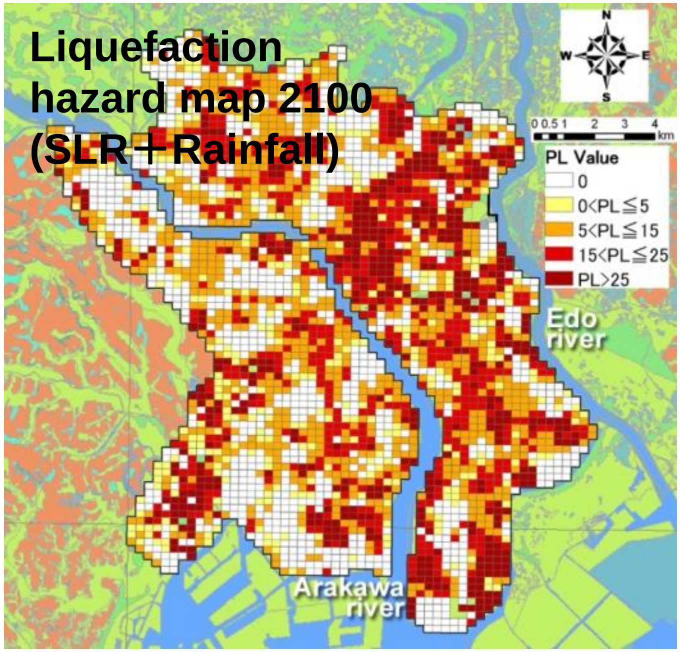
Yp: Economic loss (Yen)

Se: Minryoku-index

H: Correction value of liquefaction



Liquefaction hazard map 1990



Liquefaction hazard map 2100 (SLR＋Rainfall)

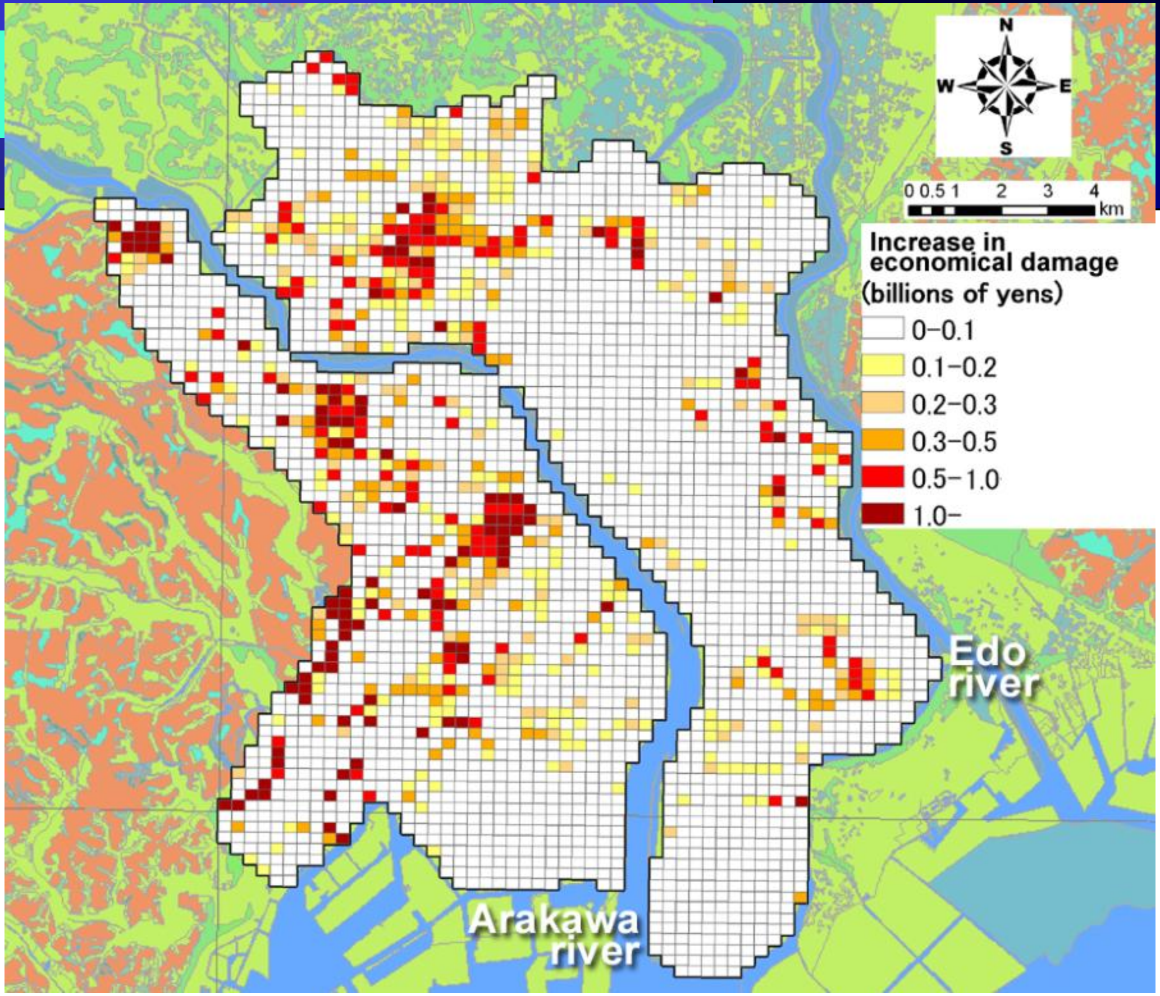


Fig. Damage of liquefaction due to SLR + climate change(rainfall)

Total damage increases about 400 bill. yen

･Inland area is higher than coastal area

→ The rising GWL can be limited since GWL is already high in coastal area. Most inland area suffers from land subsidence.

Perspectives

Options of adaptations

Table Adaptation in coastal areas

	Adaptation		
	Protection	Accommodation	Retreat
Inundation caused by storm surge	●Elevating dikes ●Coastal vegetation ●Large floodgate ●Early warning system ●Evacuation system	●Hazard maps ●Change in land use ●Protection of coastal ecosystems such as mangroves ●Strict regulations in disaster-prone areas ●Disaster insurance	●Development regulations for disaster-prone coastal areas ●Land use and regional planning ●Evacuation from highly vulnerable coastal areas ●Subsidies for relocation
River flooding	●Elevating dikes ●Blocking the water ●Early warning system ●Evacuation system	●Hazard maps ●Change in land use ●Strict regulations in disaster-prone areas ●Disaster insurance	●Land use and regional planning ●Evacuation from highly vulnerable coastal areas ●Subsidies for relocation
Liquefaction	●Monitoring ground water level ●Elevating ground ●Reinforcement of ground	●Hazard maps ●Change in land use ●Strict regulations in disaster-prone areas ●Disaster insurance	●Land use and regional planning ●Evacuation from highly vulnerable coastal areas ●Subsidies for relocation
Slope disaster	●Prevention pile ●Early warning system ●Evacuation system	●Hazard maps ●Risk maps ●Strict regulations in disaster-prone areas ●Disaster insurance	●Land use and regional planning ●Evacuation from highly vulnerable coastal areas ●Subsidies for relocation

Conclusion

- We analyze climate-change-induced natural hazards near coasts and rivers, and in relevant inland areas.
- In terms of climate impact function, the study implies that there is no clear threshold between inundation and climate impacts such as sea level rise and storm surge.
- We estimate economic losses induced by climate change.
  - from the viewpoints of water damage, such as that by storm surge and inundation, and geotechnical damage such as liquefaction and slope disaster.
  - Loss of stock or flow
- We seek to present appropriate adaptation strategies and techniques that correspond to each site, where different traditions, cultural backgrounds, and different ways of life must exist.
- For that reason, a concept and a menu for adaptation to climate-induced natural hazards is tentatively proposed.
  - Cost-benefit analysis is near future target.
- Based on the summation of experiences and case studies, this must reflect policy-making against disaster reduction, economic loss, and for finding the most suitable adaptation techniques.

Thank you for your attention!