Effects of Climate Change on Natural Disasters at Coastal Zones

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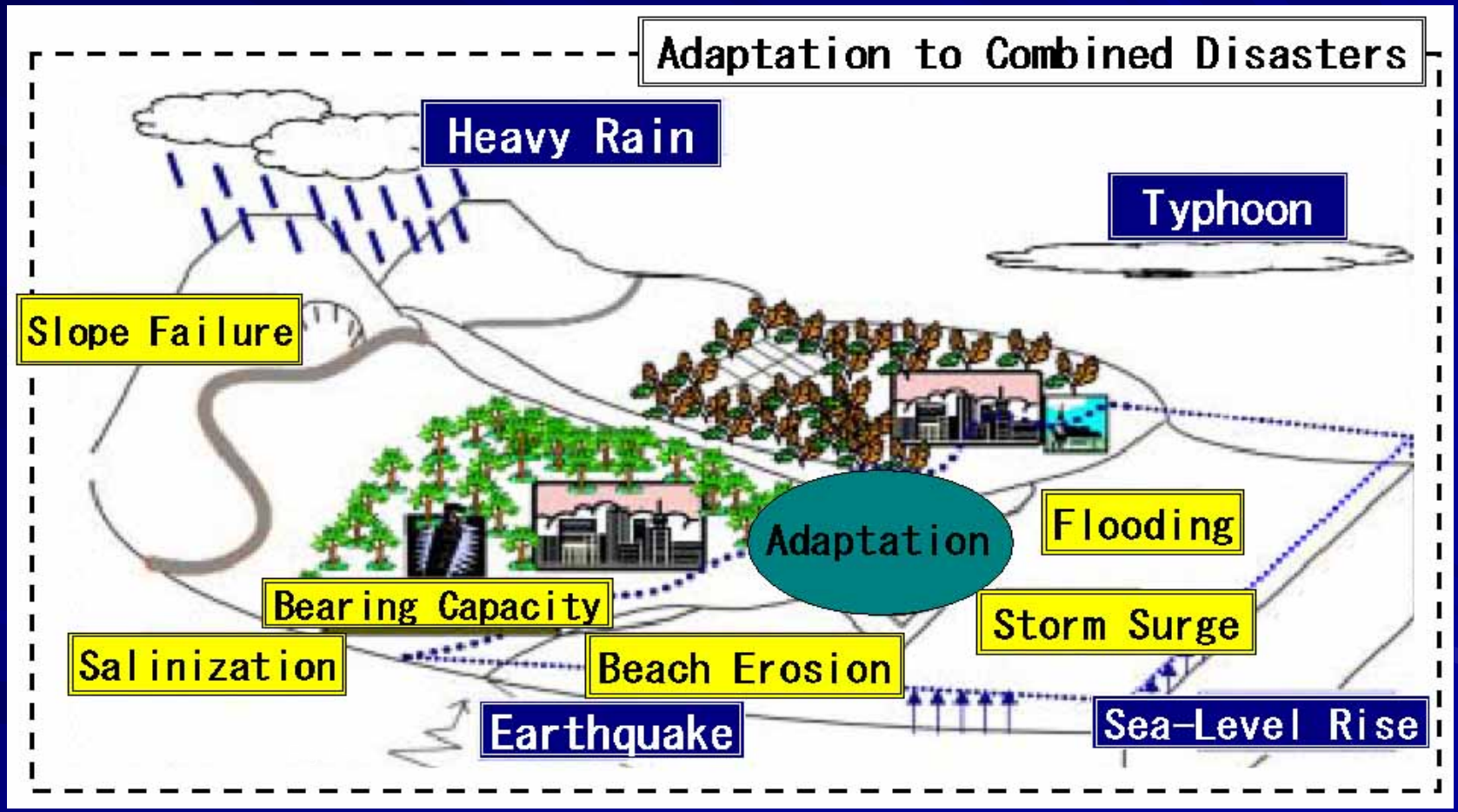
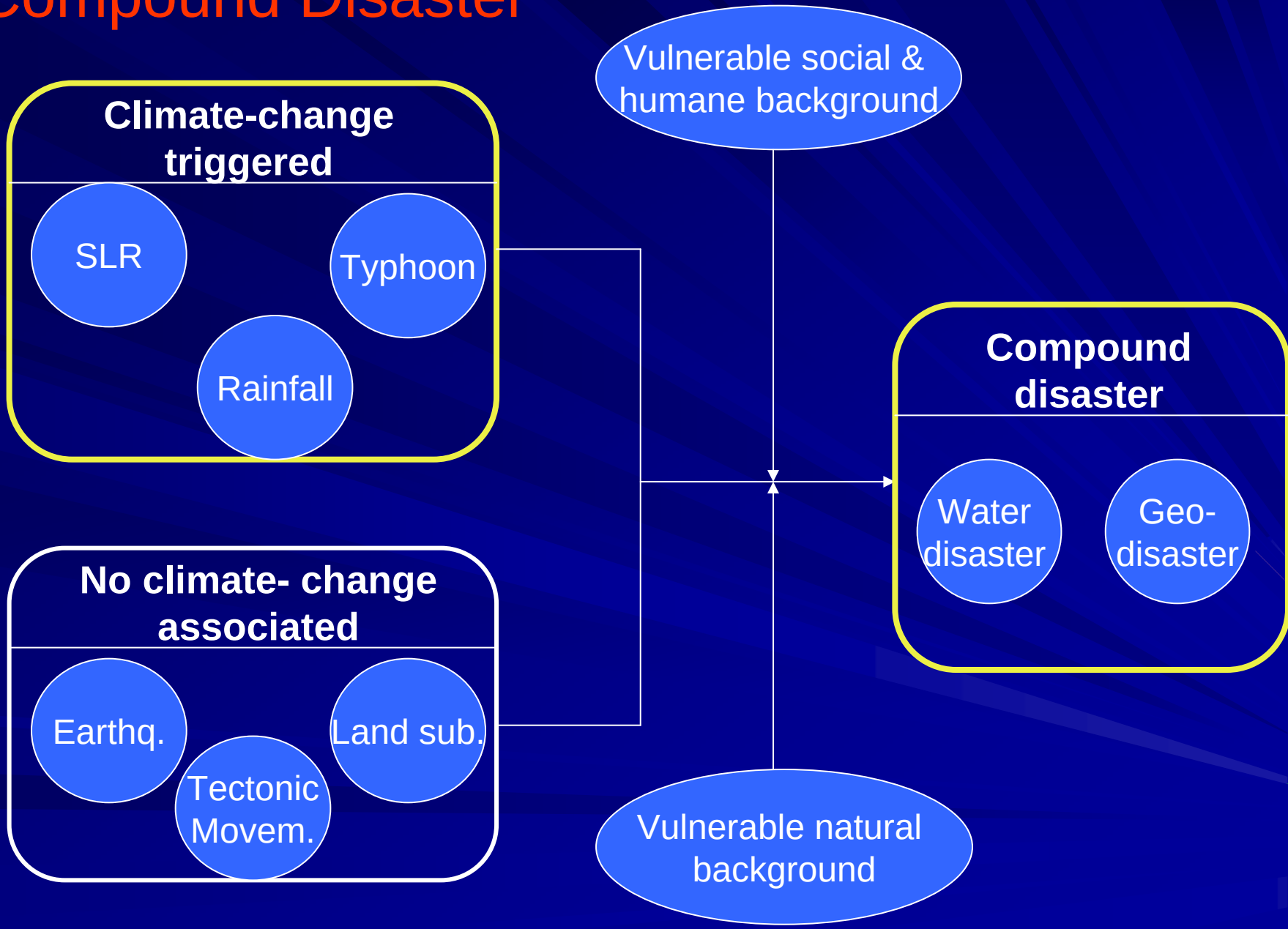
Research program by coastal hazard and adaptation group

- (1) Climate-change susceptible function for economic assessment
- **(2) Coastal hazards induced by a rising sea level, storm surges and river floods: adaptation strategies and assessment of submergence and risks**
- (3) Prediction and adaptation to damage of riverbanks and coastal grounds resulting from rising sea-levels caused by global warming
- **(4) Geo-hazards triggered by climate change and great earthquakes: evaluation and adaptation strategies**
- (5) Assessing risks of heavy rains and rising sea-levels caused by global warming in coastal areas

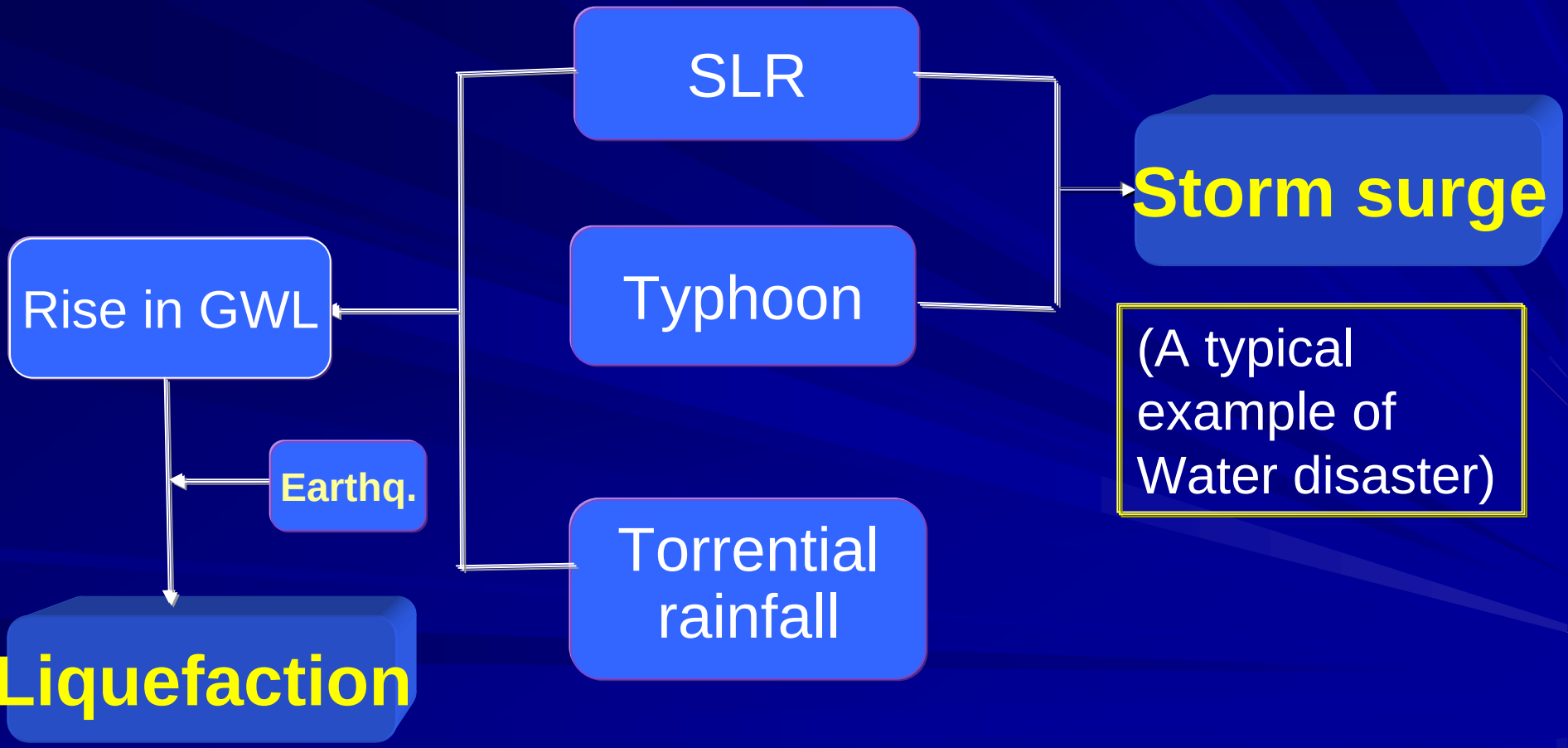
Disasters caused by overlapping of multiple phenomena triggered by global warming



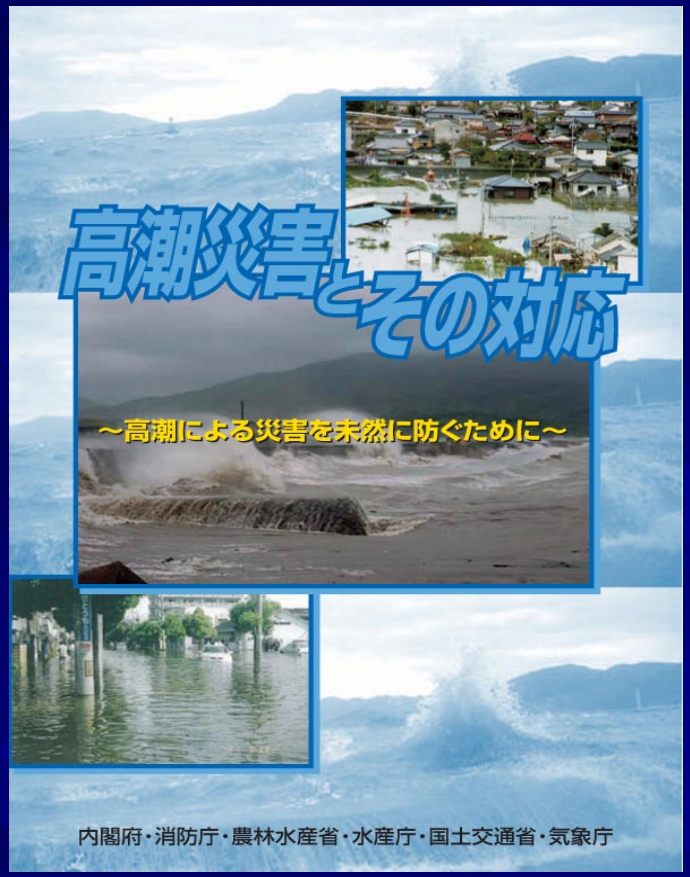
Compound Disaster

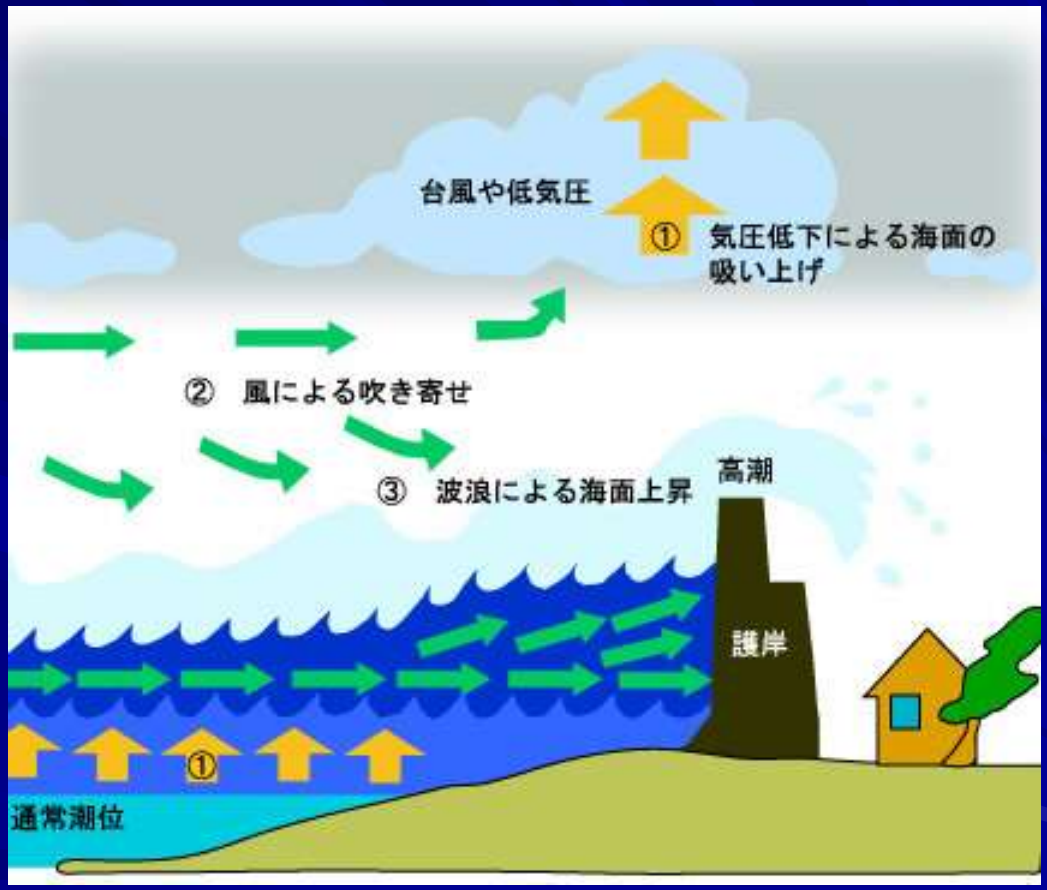


Examples of global warming-triggered events



Storm Surge


高潮災害とその対応
～高潮による災害を未然に防ぐために～
内閣府・消防庁・農林水産省・水産庁・国土交通省・気象庁


台風や低気圧
① 気圧低下による海面の吸い上げ
② 風による吹き寄せ
③ 波浪による海面上昇
高潮
護岸
①
通常潮位

Storm surge and river inundation

Storm surge
(West-Japan)

River flooding
(4 main rivers)

SLR, Typhoon

Topographical data

Population and economic data

Flooding (Level flood method)

Damage of inundated area

- **Area**
- **Population**
- **Cost**

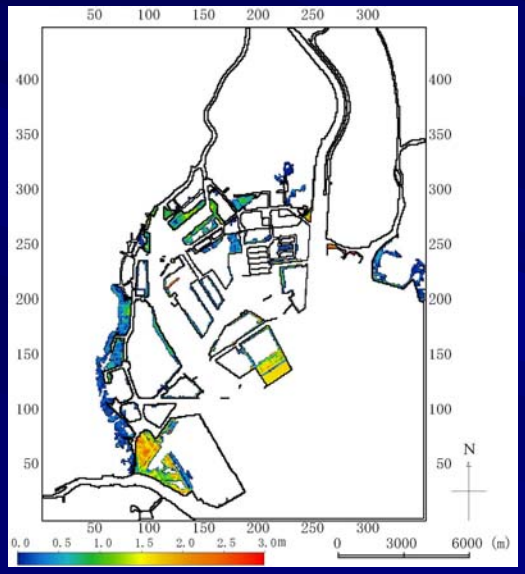
Decrease in Agricultural productivity

Damage cost (assets/stock)

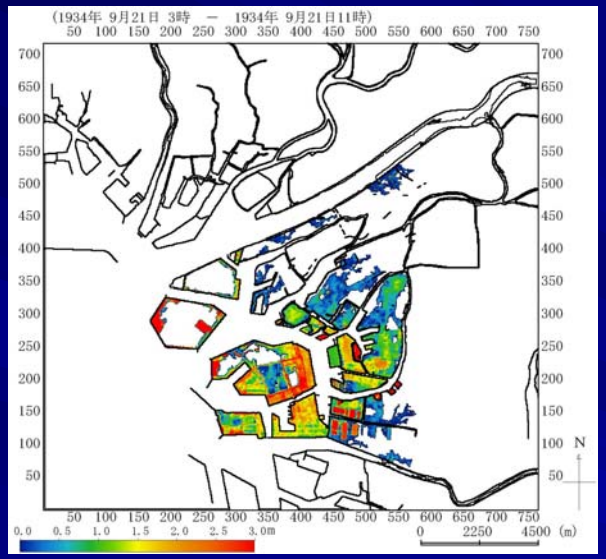
Indirect effects to the economy (productivity/flow)

Inundation at the three major Bays

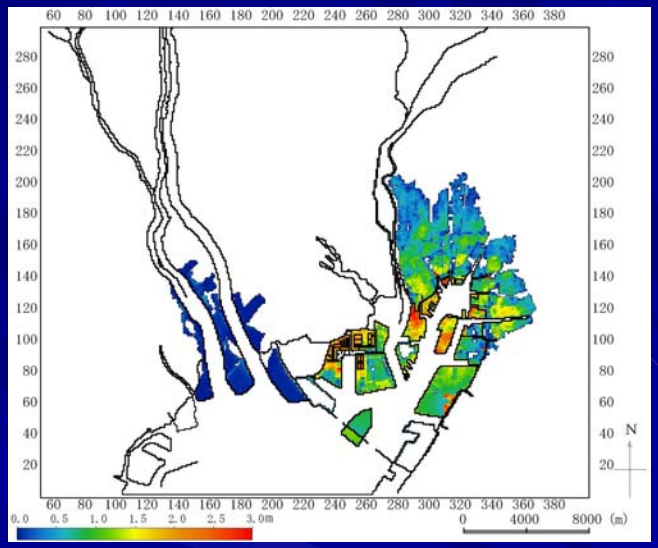
（SLR 60cm，storm surge increase ratio 1.3 at 2030）



(a) Tokyo Bay



(b) Ise Bay



（c）Osaka Bay

Inundation caused by storm surge increases at the lowland and reclamation area at the three bays.

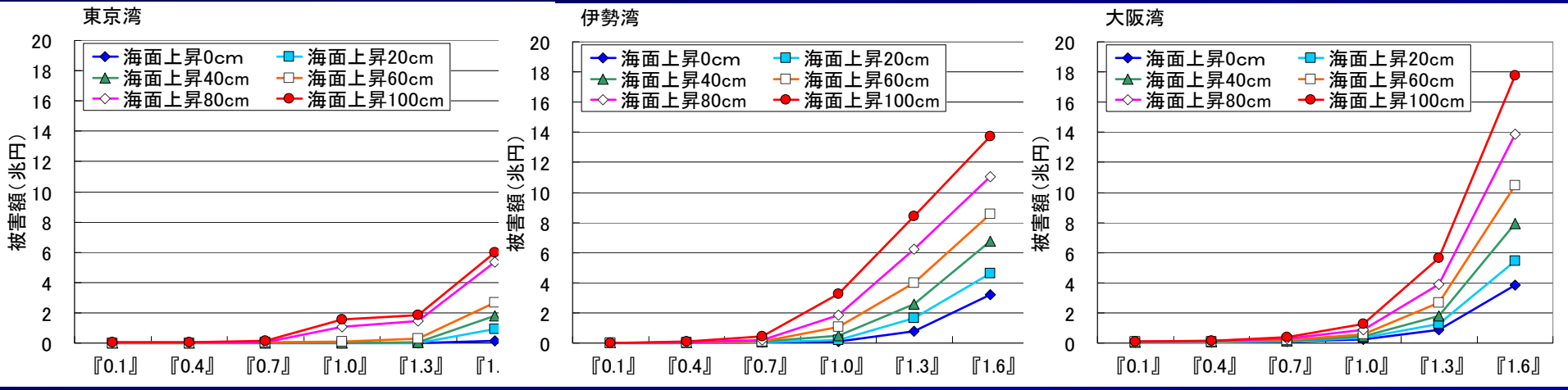
(After Suzuki, 2007)

Variation of inundation damage

(a) Tokyo Bay

(b) Ise Bay (Nagoya)

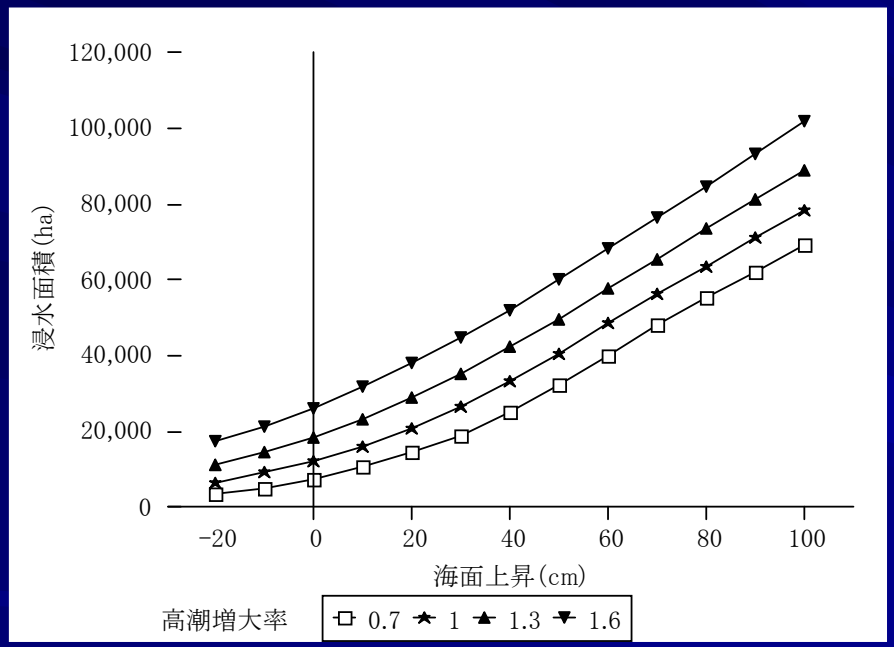
© Osaka Bay



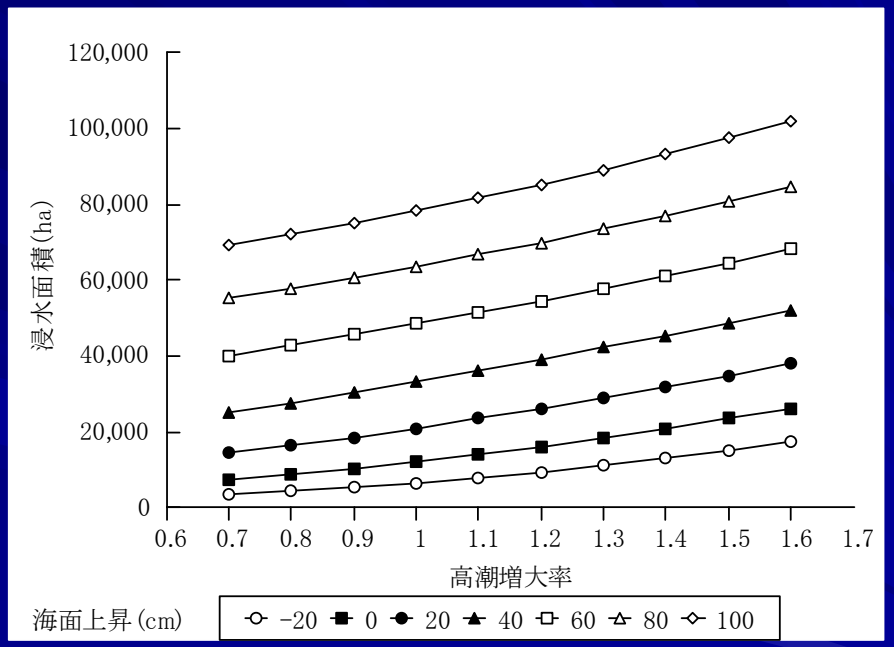
Intensity of typhoon
(Isewan-Typhoon as a standard)

(Estimation is based on the manual of MLIT)

Change in inundation area in the Pacific coast



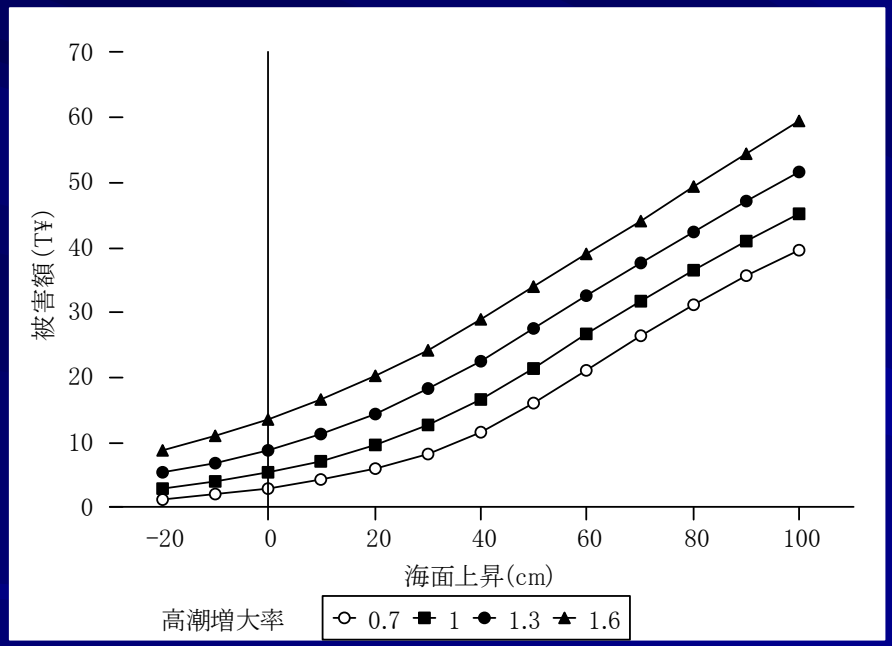
(a) Influence of SLR



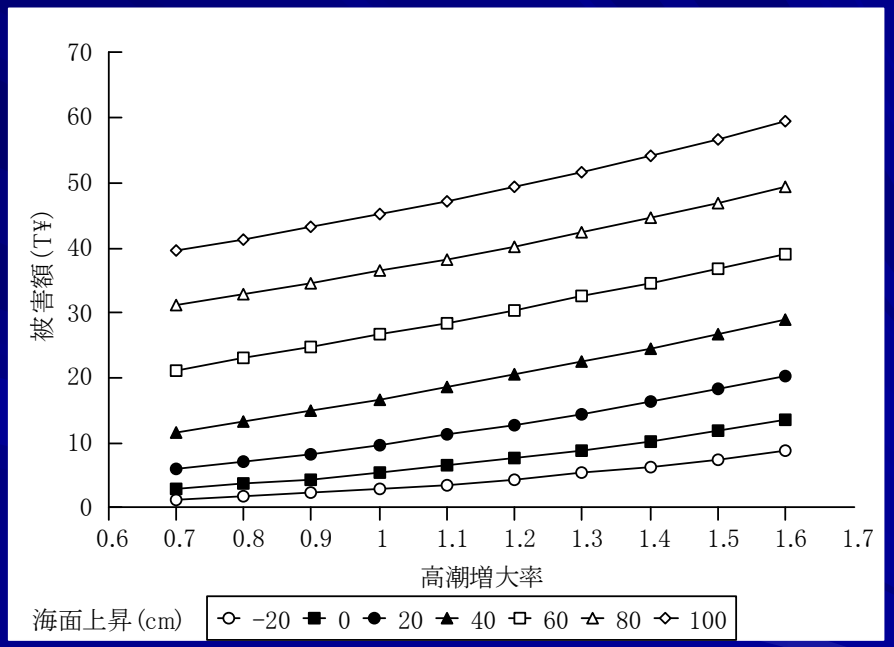
(b) Influence of SSIR

Inundation area is sensitive to SLR.

Change in economical loss caused by storm surge in the Pacific coast



(a) Influence of SLR



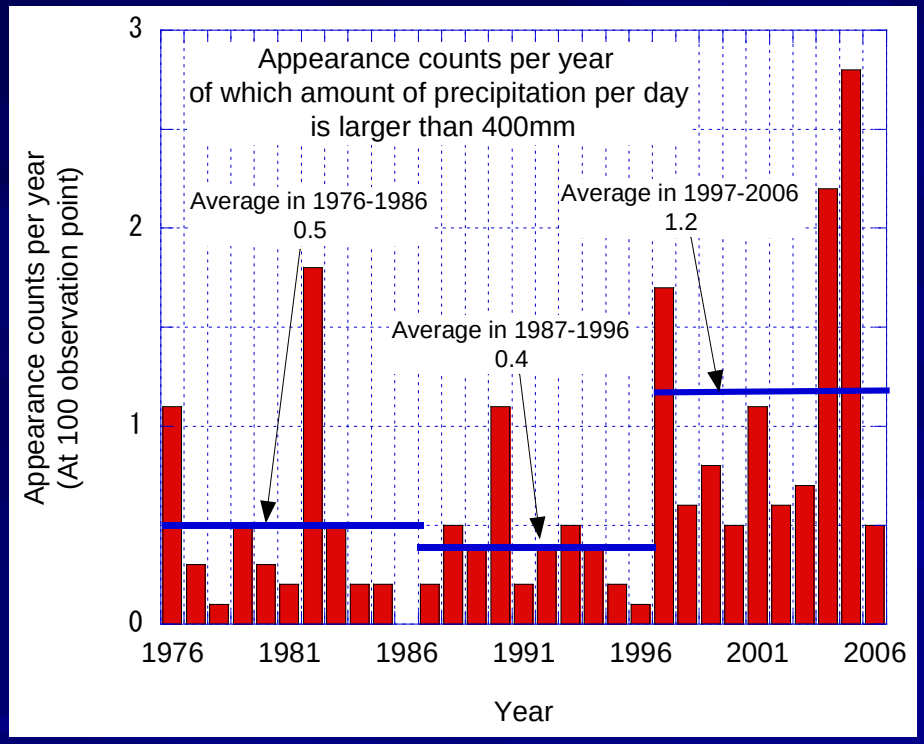
(b) Influence of SSIR

Inundation damage cost is also sensitive to SLR.

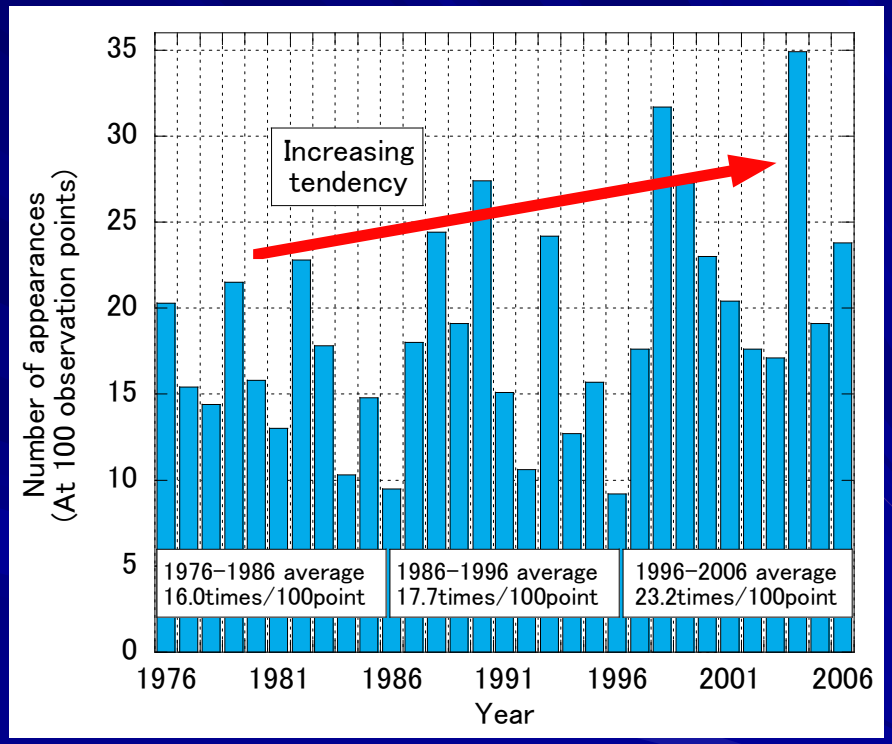
Liquefaction

(Great Hanshin Earthquake, 1995, Japan)

Recent situation of rainfall in Japan (after JMA, 2006)

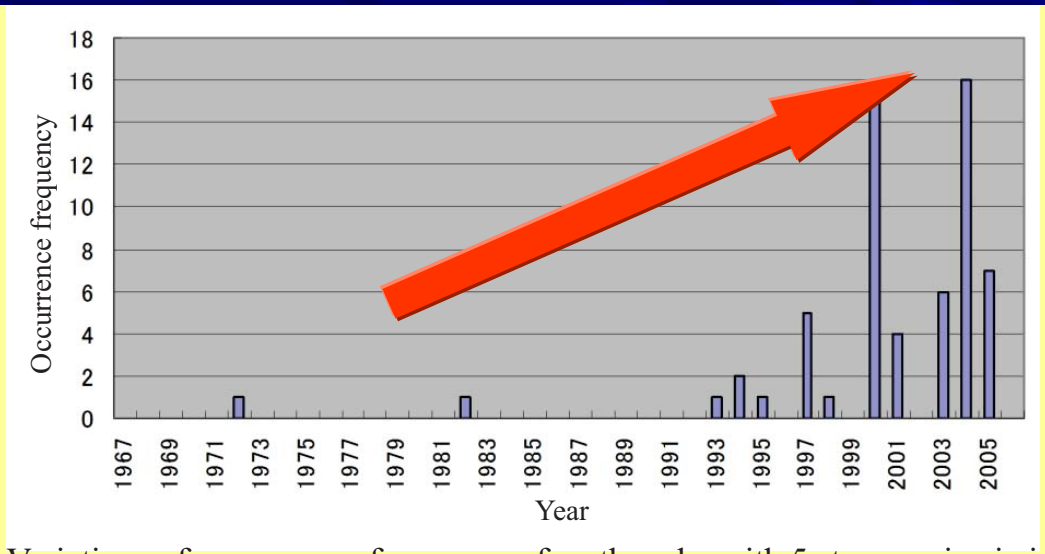


(a)Appearance counts per year larger than 400mm in Japan

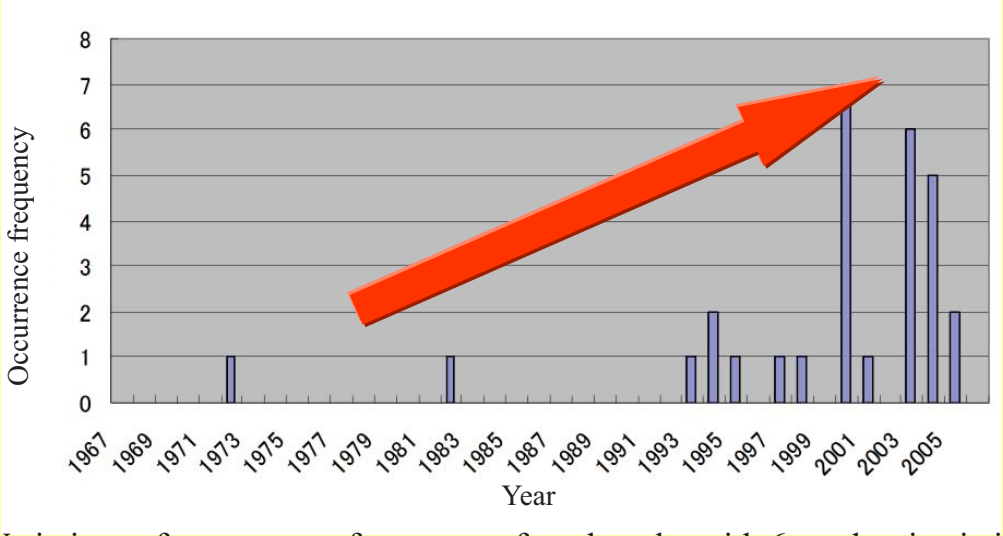


(b) Number of appearance larger than 50mm in Japan

Occurrence frequency of recent earthquakes in Japan (arranged using data from JMA, 2006)



(a) Variations of occurrence frequency of earthquake with 5 strong seismic intensity

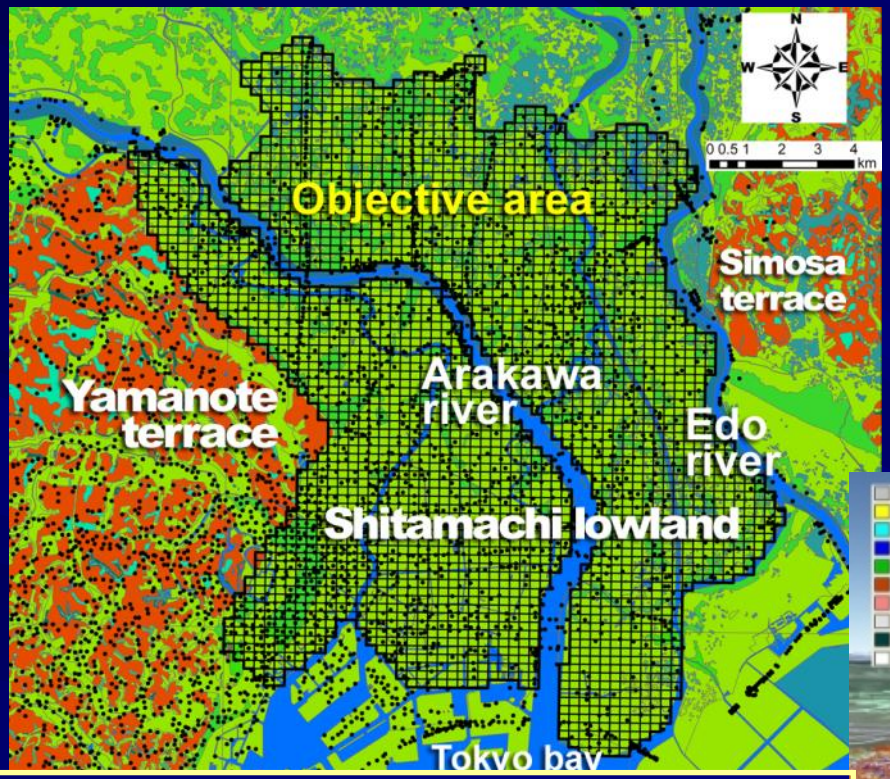


(b) Variations of occurrence frequency of earthquake with 6 weak seismic intensity

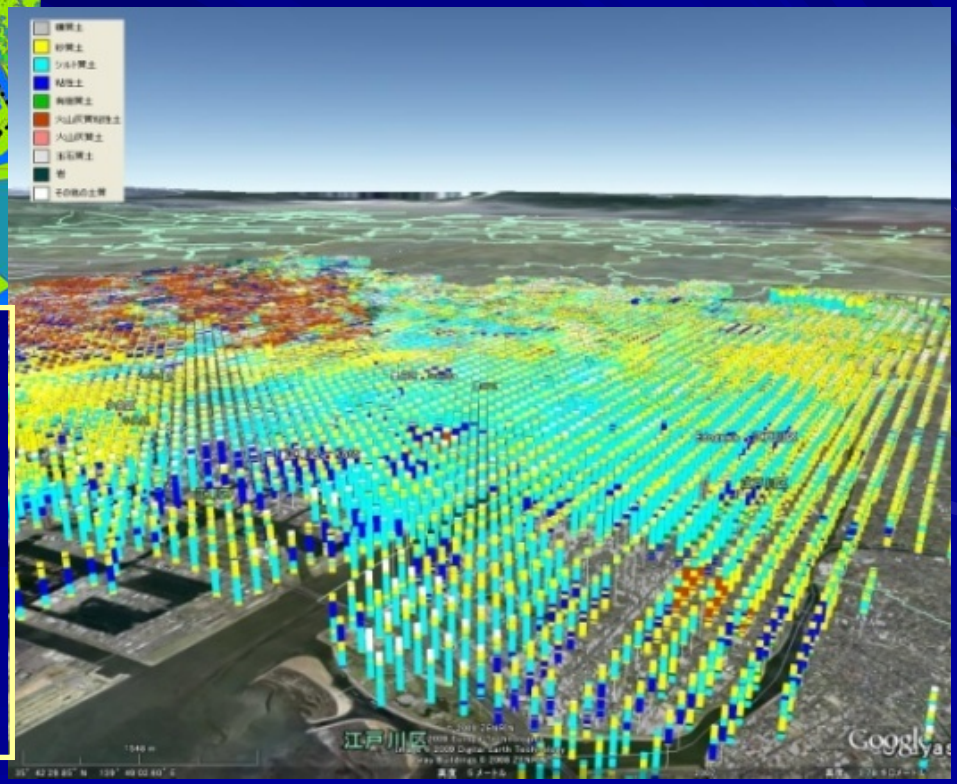
Purpose

Vulnerability to liquefaction hazards in the objective region has been assessed through comparison of GIS-aided liquefaction hazard maps before and after SLR and climate change caused by global warming.

Economical loss for eastern lowland of Tokyo

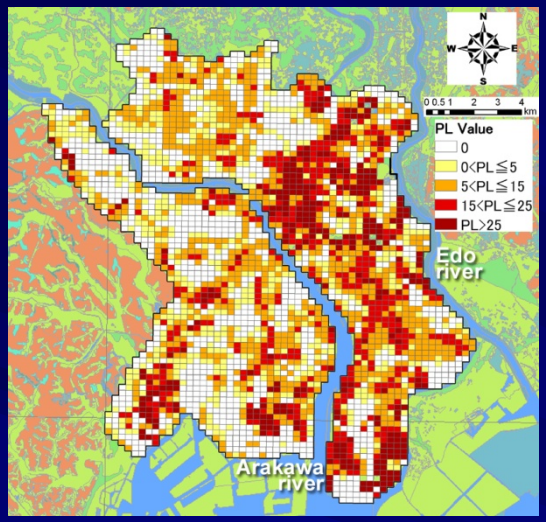


Objective area: coastal area in the eastern part of Tokyo

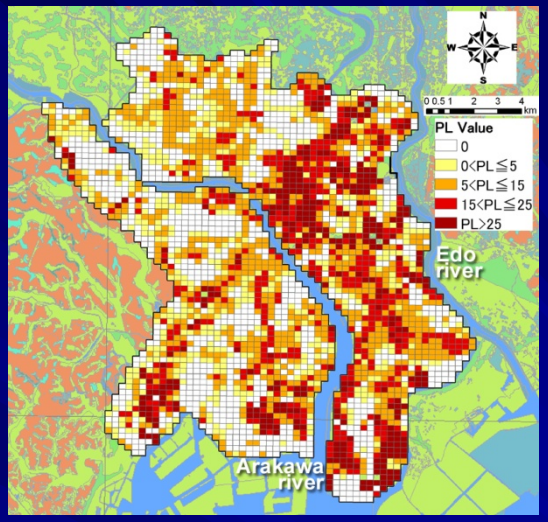


- Collection of ground data
- Ground modeling
- Estimation of rise in GWL caused by climate change and SLR
- Estimation of economic loss

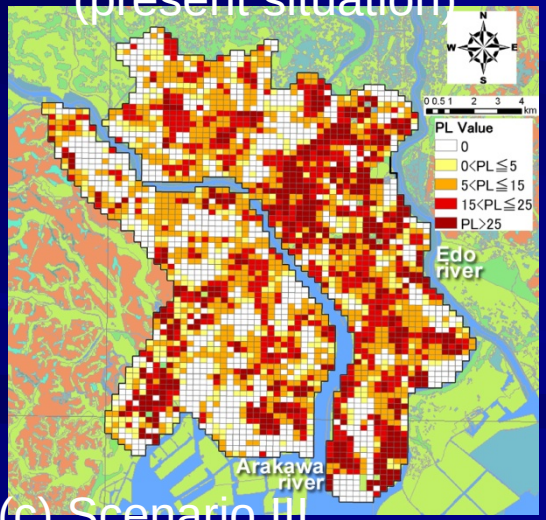
Distribution of liquefaction hazard



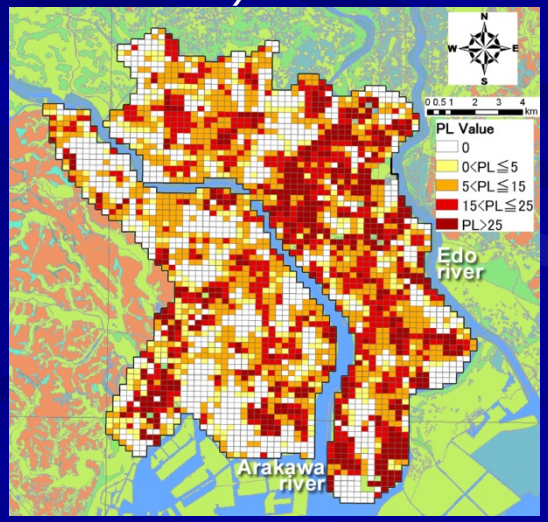
(a) Scenario I (present situation)



(b) Scenario II(consideration of SLR in 2100)

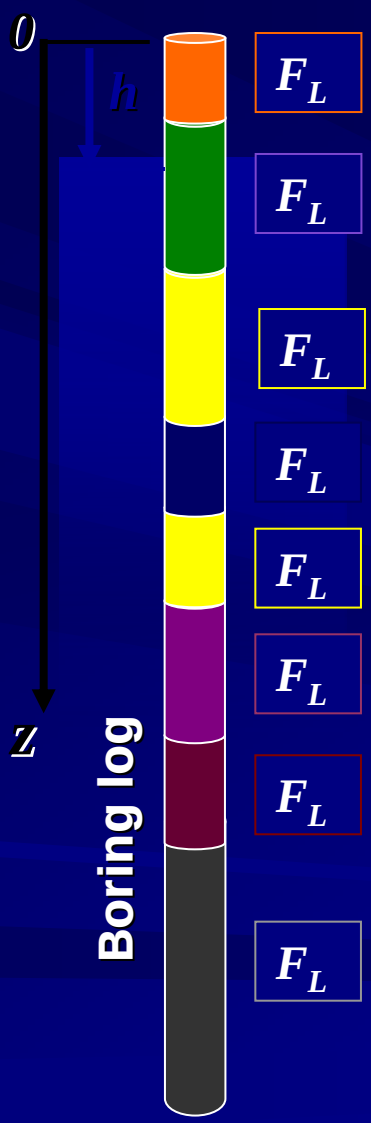


(c) Scenario III (consideration of rainfall from 2081 to 2100)



(d) Scenario IIV(both SLR and rainfall from 2081 to 2100)

Evaluation of possible liquefaction through depth in an objective location using the method proposed by Iwasaki et al.(1996)



Liquefaction resistance factor, F_L

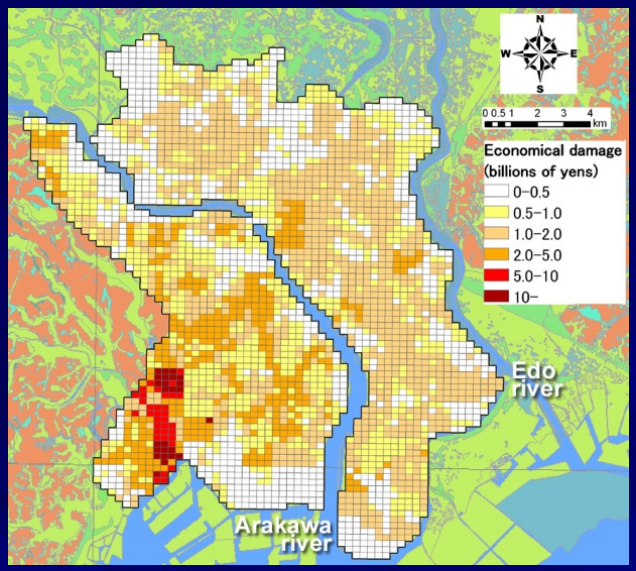
$$P_L = \int_0^{20} F(z)w(z)dz$$

$$F(z) = \begin{cases} 1 - F_L & F_L \le 1 \\ 0 & F_L > 1 \end{cases}$$

$$w(z) = 10.0 - 0.5z$$

Integration of the liquefaction potential through depth, using this equation

Distribution of economical damage caused by earthquake



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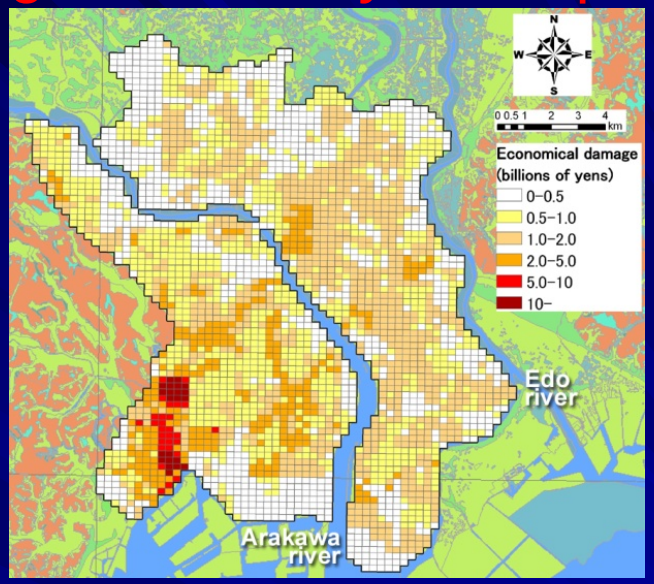
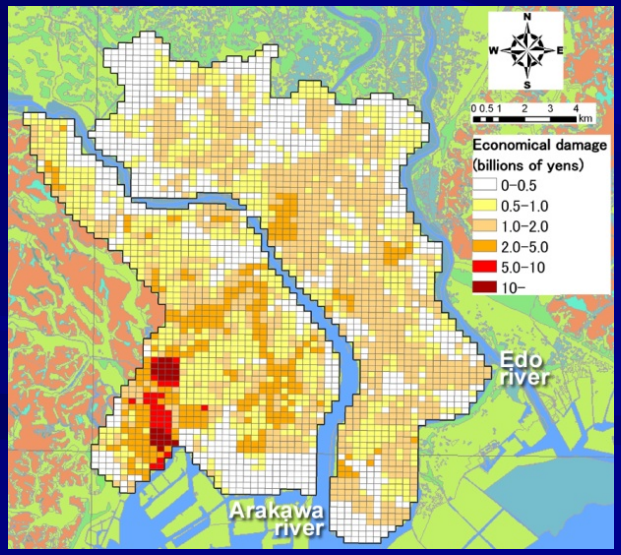
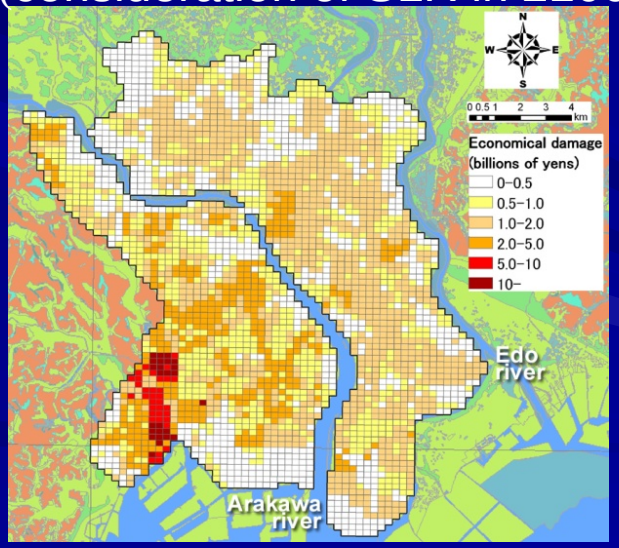


(b) Scenario II
(consideration of SLR in 2100)



(c) Scenario III (consideration of rainfall from 2081 to 2100)

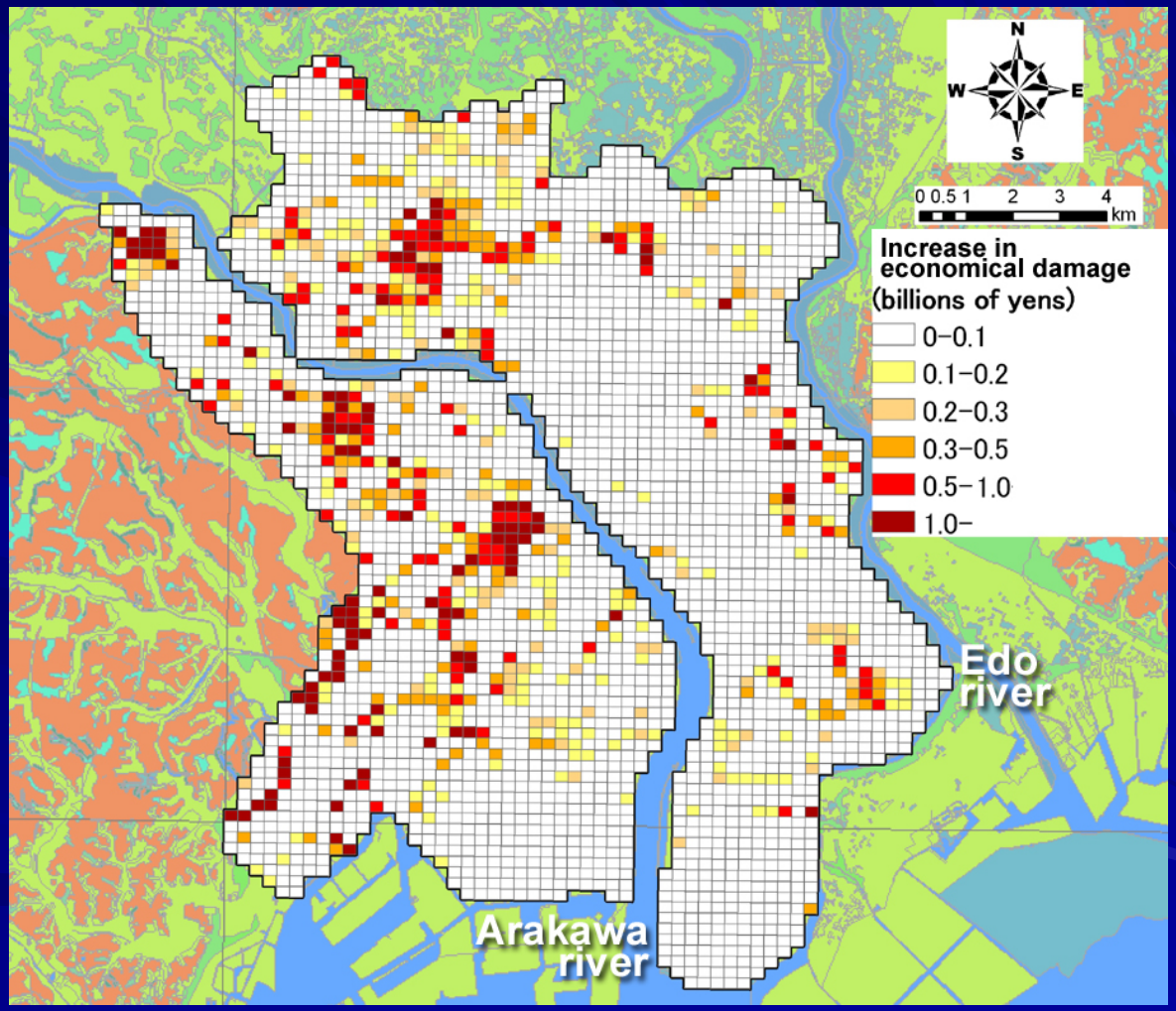


(d) Scenario IV (both SLR and rainfall from 2081 to 2100)

Increase in economic damage from the present situation to the scenario IV

Liquefaction damage has appeared rather in land than along the coast.

Economical loss induced by liquefaction is 4 thousand billion Yen approximately in the case of both SLR and heavy rainfall considered.



Possible adaptation to natural disasters at coastal zones

		Adaptation	
	Protection	**Accommodation**	**Evacuation**
Storm surge & River flood	**Additional banking Water protection work Early warning system and evacuation system Construction of shelter**	**Hazard map Appropriate land use Regulation of land use in hazardous area Insurance**	**Restriction of development Evacuation from dangerous area Public support for evacuation**
Lique-faction	**Monitoring of GWL Lowering of GWL Additional banking Soil improvement and reinforcement**	**Hazard map Appropriate land use Regulation of land use in hazardous area Insurance**	**Restriction of land use Evacuation from dangerous area Public support for evacuation**
Slope failure	**Protective pile Early warning system and evacuation system**	**Hazard map Risk map Regulation of land use in hazardous area Insurance**	**Restriction of land use Evacuation from dangerous area Public support for evacuation**

Conclusion

- 1) Sea level rise and buildup of high tides triggered by global warming expand the flooding area and population. As global warming progresses, reclaimed lands developed long ago will face a high risk of flooding by high tides in the inner parts of the three large bays.

- 2) Sea level rise and anomalous rainfall raise the groundwater level and expand areas that suffer geotechnical hazards through liquefaction in the event of an earthquake.

- 3) The procedures for estimating economical loss induced by storm surge and liquefaction are presented. The results should be put to good account for proposal of the appropriate adaptation.