

Sub-task V.

Adaptation strategies for future changes in hazards and society

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Research Objectives

Integrated assessment of coastal flood risk under climate change considering future change of not only hazards but also exposure and vulnerability.

Hazards

Increasing coastal flooding risk due to climate change

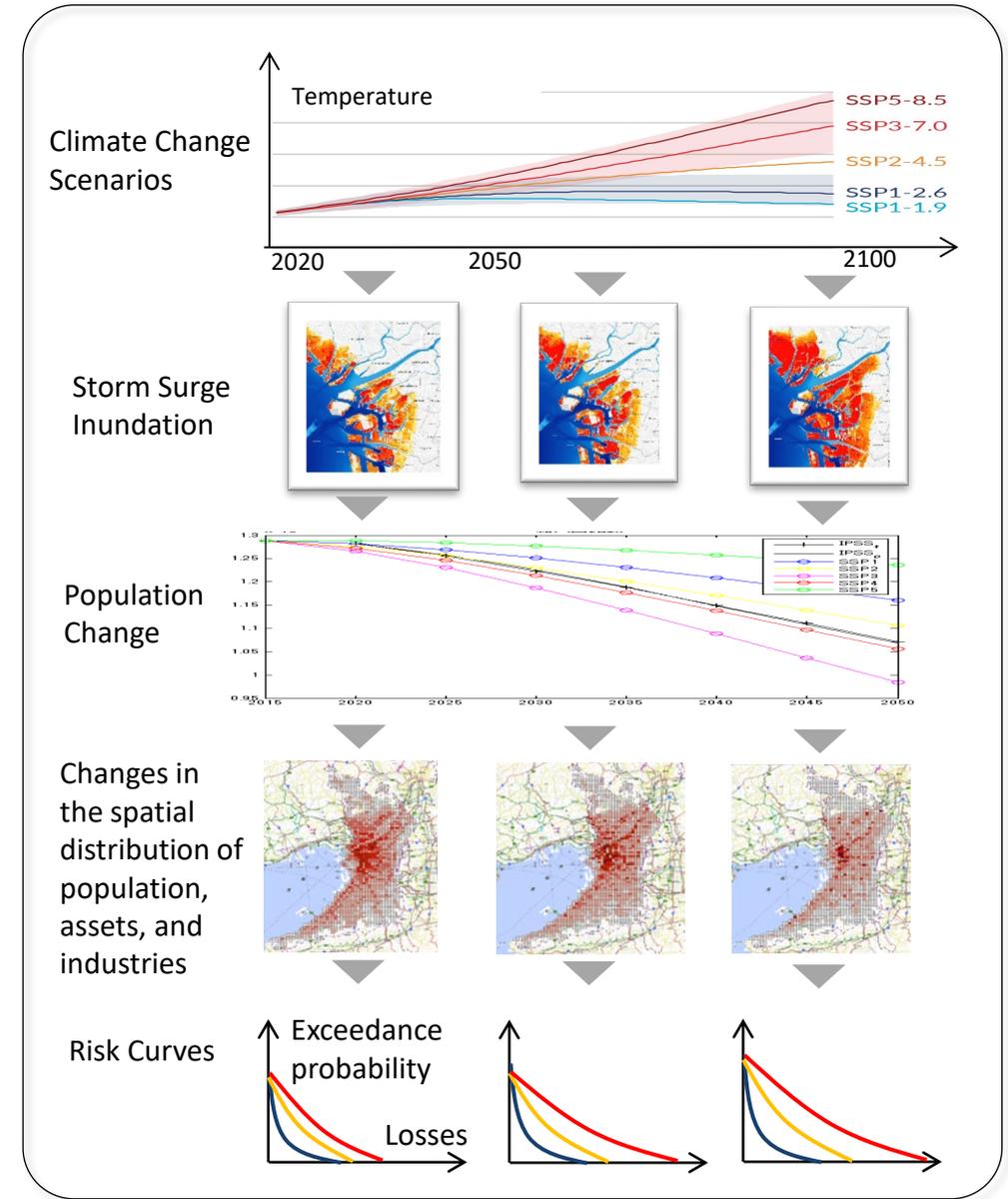
Exposure

Population decline driven by low birth rate

Vulnerability

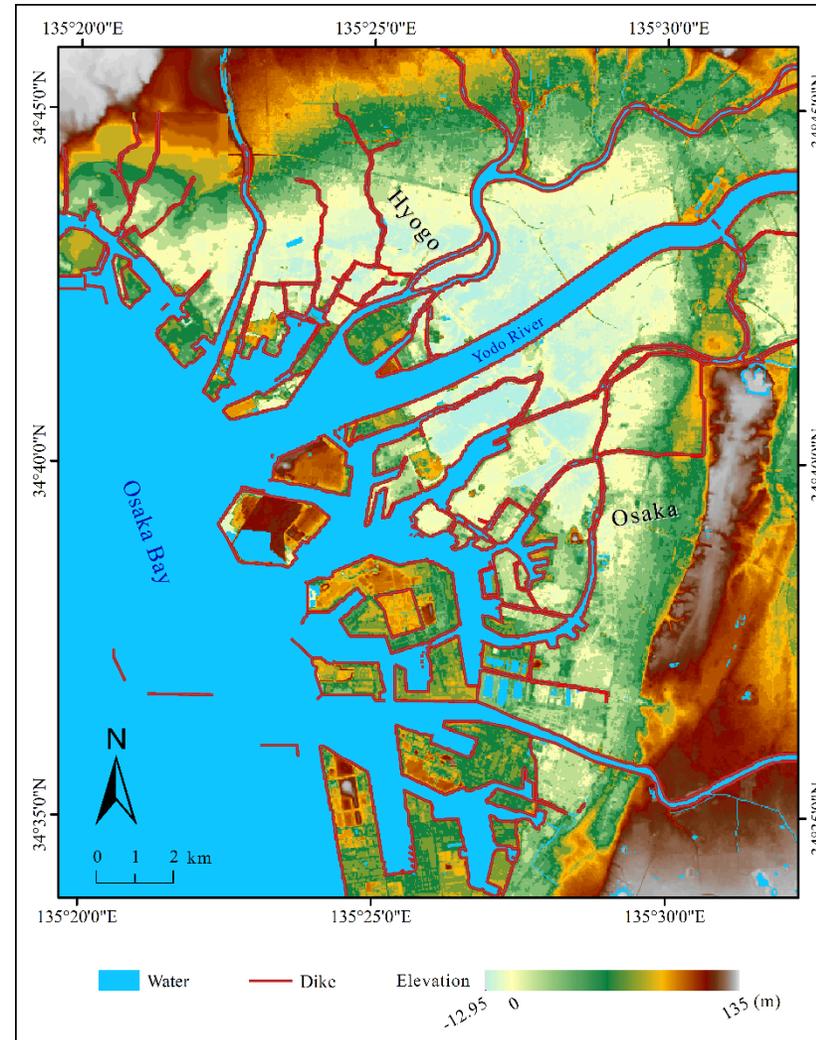
Decline in disaster-avoidance capacity due to **population aging**

Exceedance probability curves of economic losses and casualties



Target area

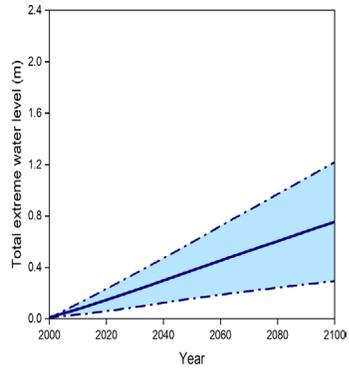
- Osaka Bay, is the second-largest economic region in Japan, with a population of 6 million approximately.
- Osaka Bay is highly developed in terms of industry, economy, and culture. However, due to its low-lying topography, the area is prone to coastal flooding, about **124 km²** of land **below mean sea level at high tide**.



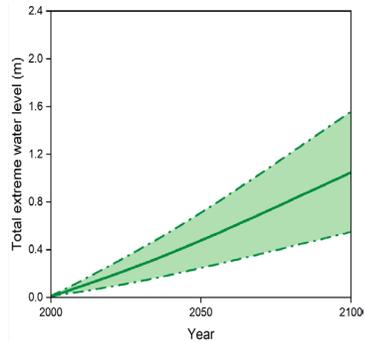
Projection of future flood hazards

Sea level rises

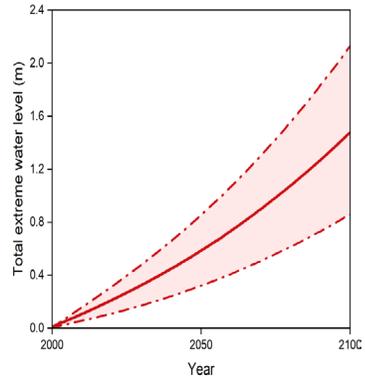
RCP2.6



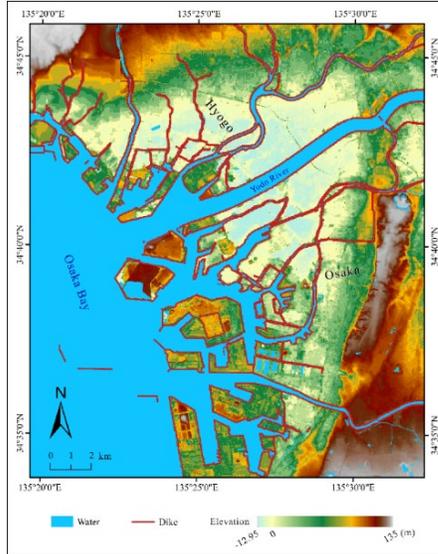
RCP4.5



RCP8.5



Target area: Osaka bay

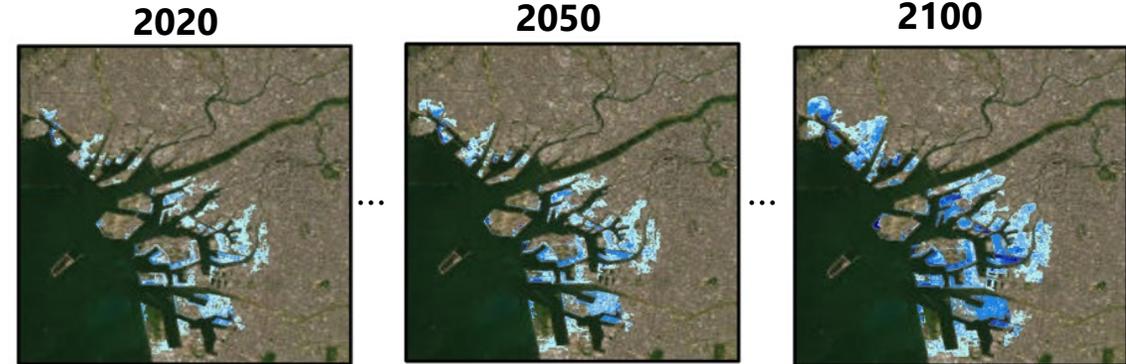


Storm surge inundation analysis by stochastic typhoon model in each RCP scenario

Flood inundation maps at 1/50 to 1/5000 levels for each RCP scenario

E.g. flood inundation simulations at 1/200 level

RCP2.6



2050



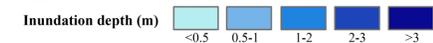
2100



RCP4.5

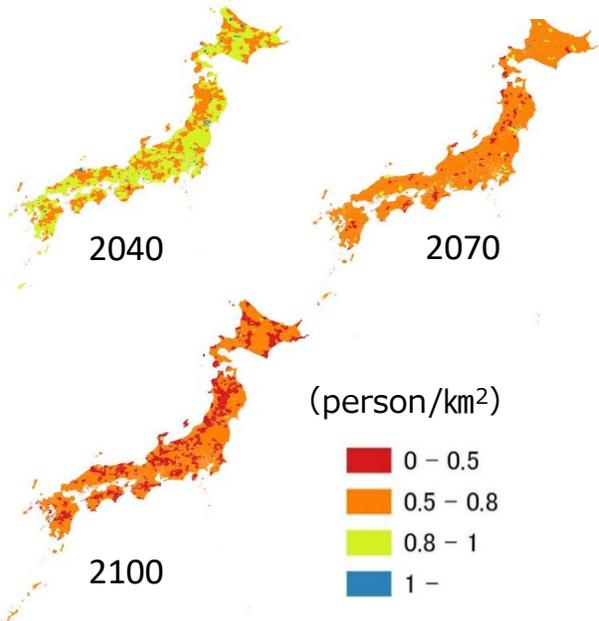
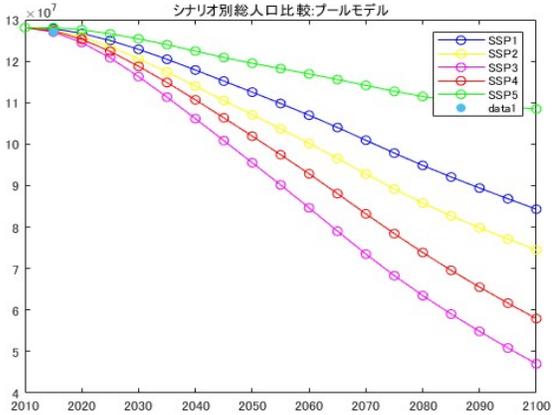


RCP8.5

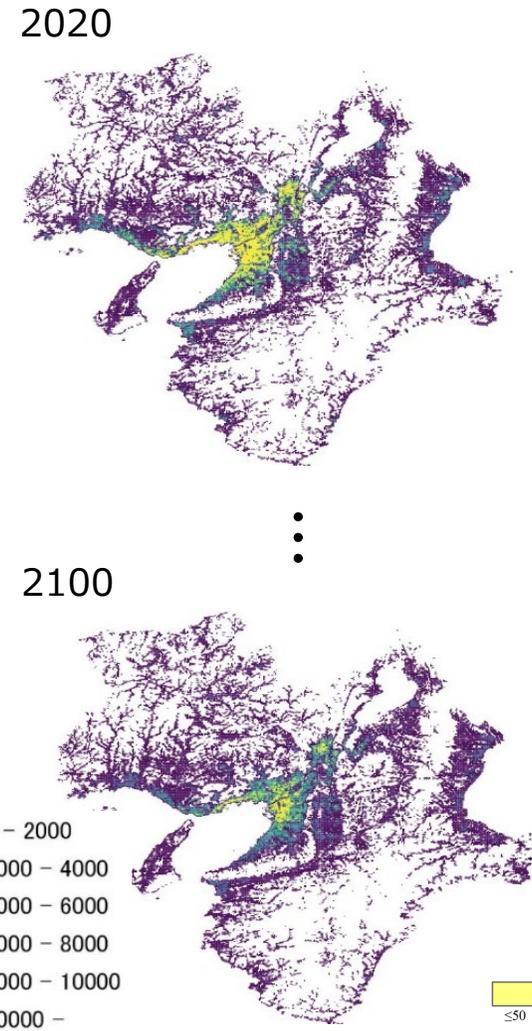


Projection of future exposures

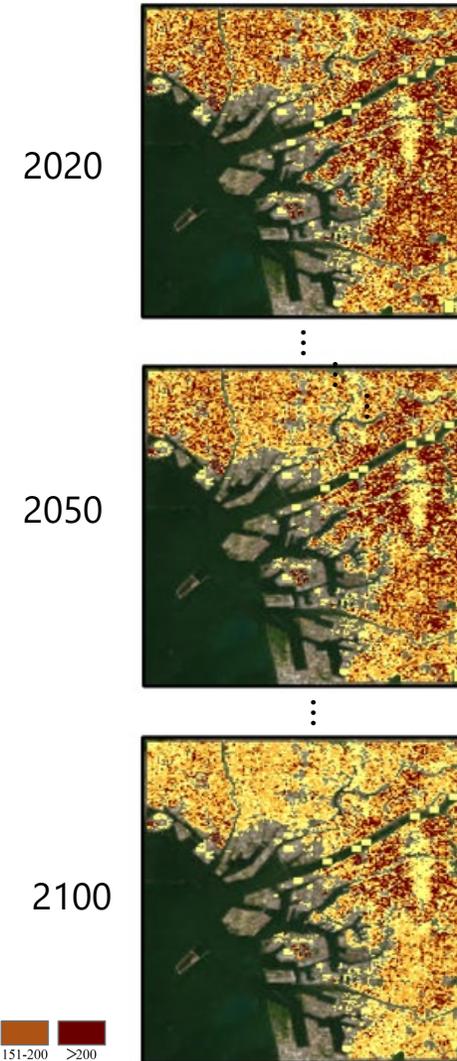
Projection of future population



Population in 100m mesh



Target area



Projection of asset distribution based on population

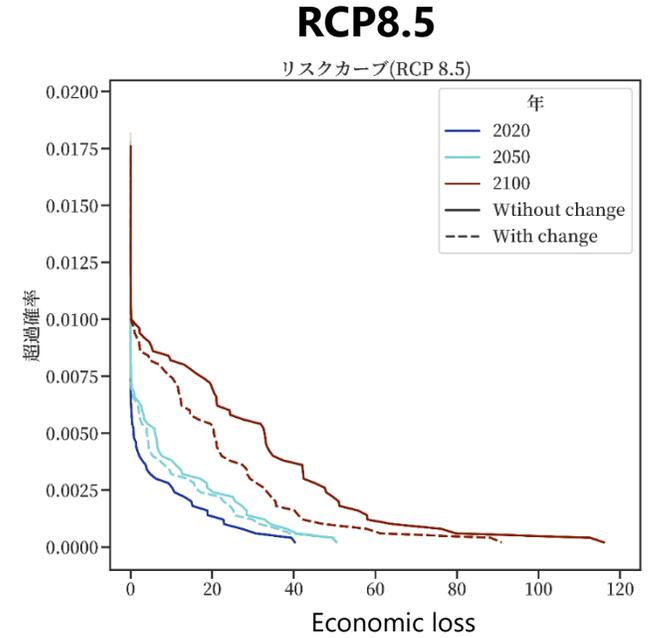
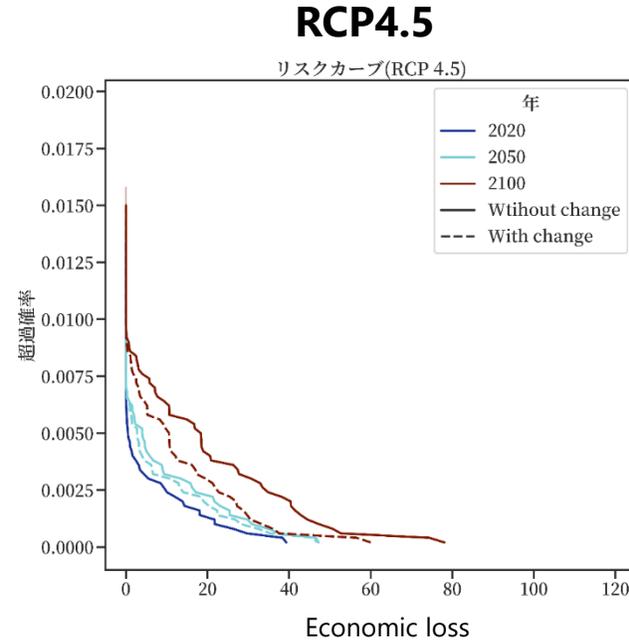
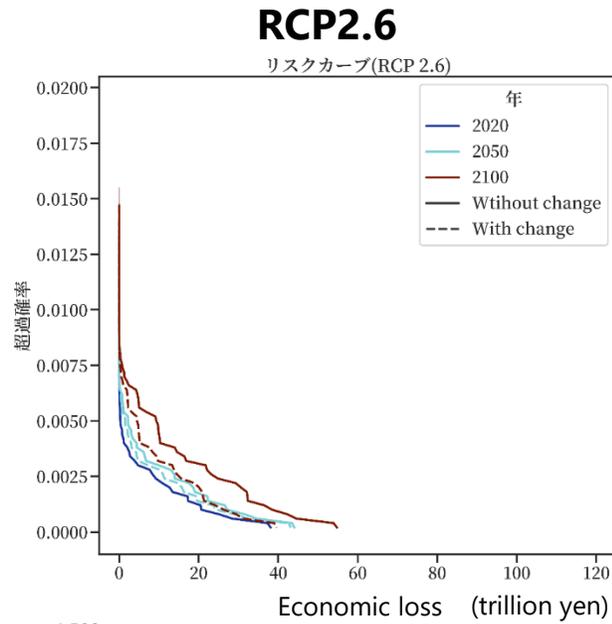
Assets

- Houses
- Factories
- Offices
- Family assets
- Business assets
- Industrial assets
- Agricultural assets
- Infrastructures

Estimation of future economic loss by combing flood inundation and asset distribution data

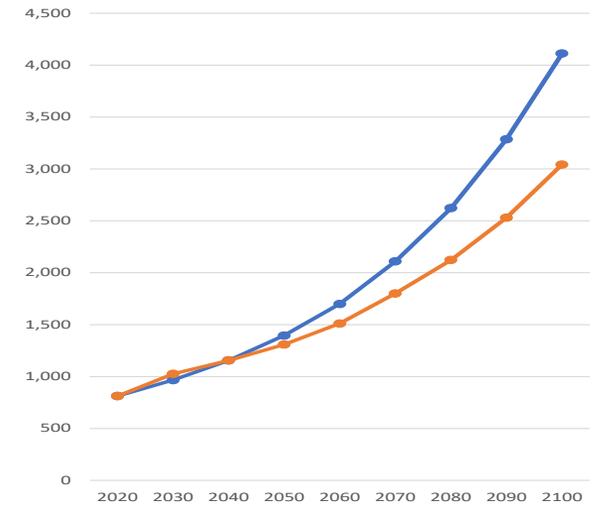
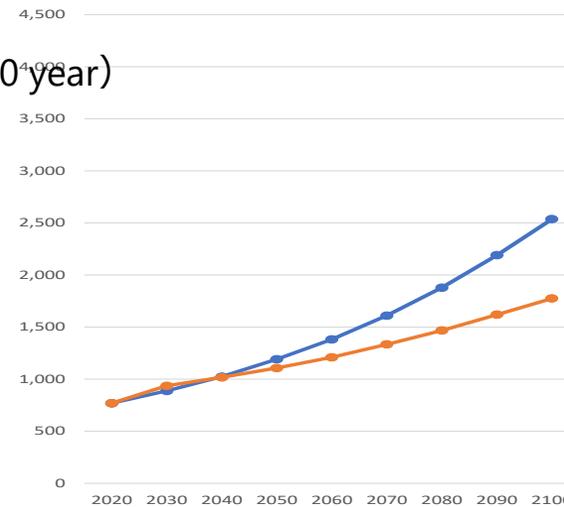
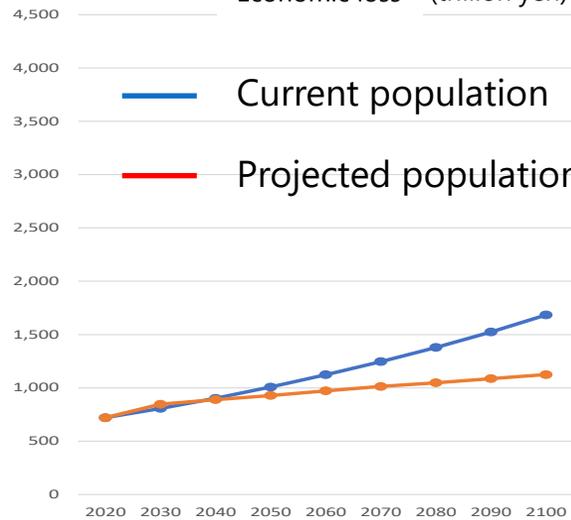
Projection of future economic losses

Exceedance Probability curves of economic loss



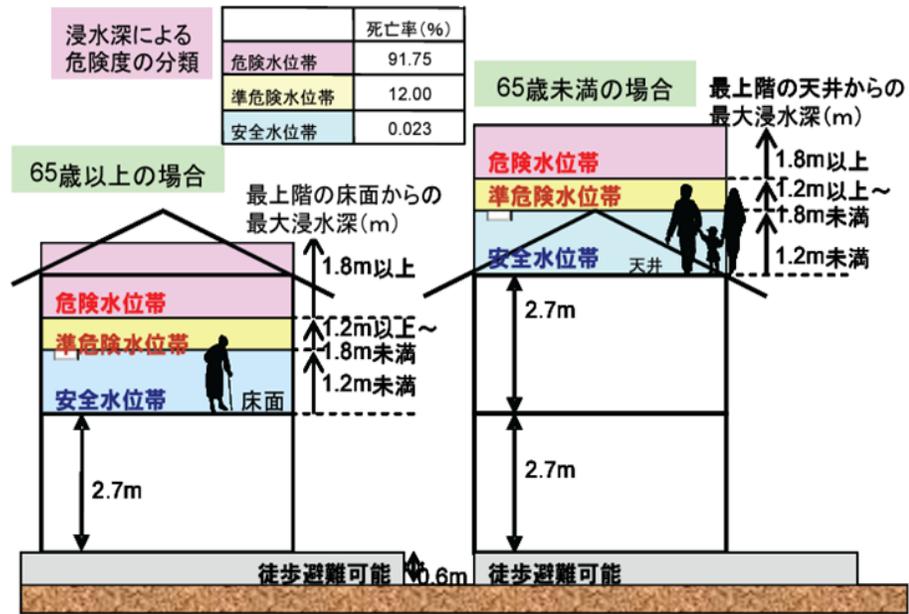
(100 million yen)

Trends of expected economic losses



Casualty Estimation Models

① LIFESim Model (U.S. Army Corps of Engineers, 2021)



$$\text{Expected Casualty} = P_0(1 - \varepsilon)s_0 + P_1(1 - \varepsilon)s_1$$

P_0 : Population Affected (≥ 65 year old)

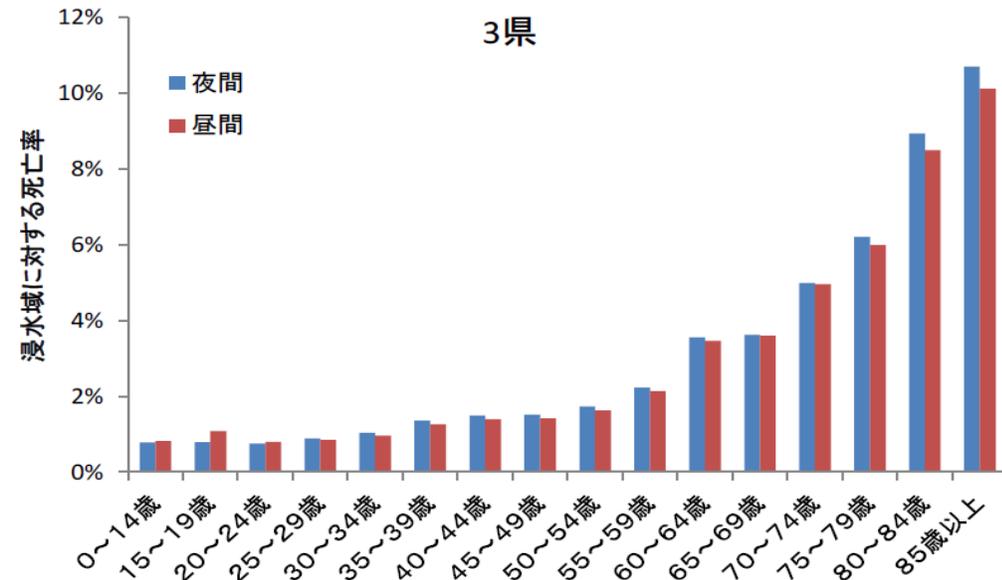
P_1 : Population Affected (< 65 year old)

s_0 : Mortality Rate of each floor height (≥ 65 year old)

s_1 : Mortality Rate of each floor height (< 65 year old)

ε : Evacuation Rate = 0.4

② Age Profile (Koyama et al., 2013) (Koyama Model)



Based on Great East Japan Earthquake Data

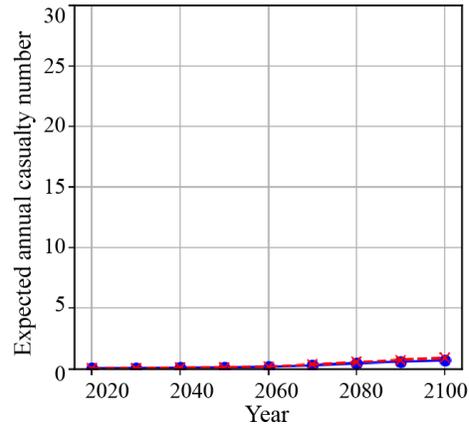
Distinguished each age group

Inundation depth threshold set at 1m

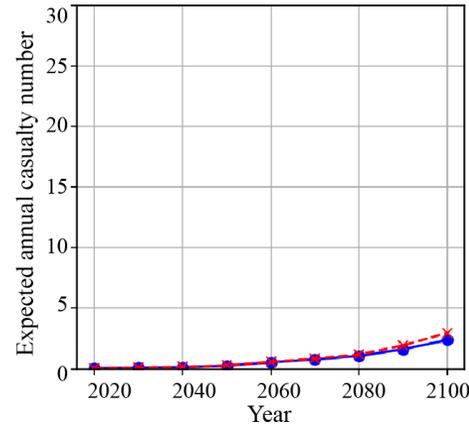
Evacuation Rate set at 40%

Results of causality estimations

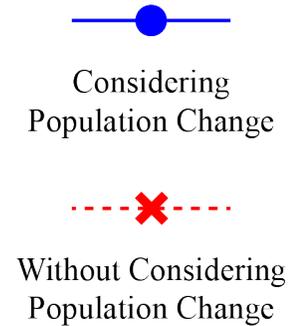
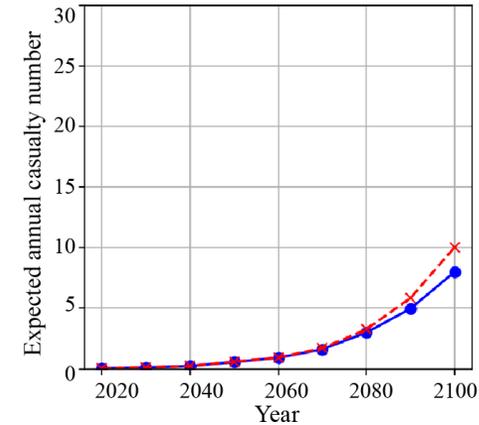
RCP2.6, LifeSim Model



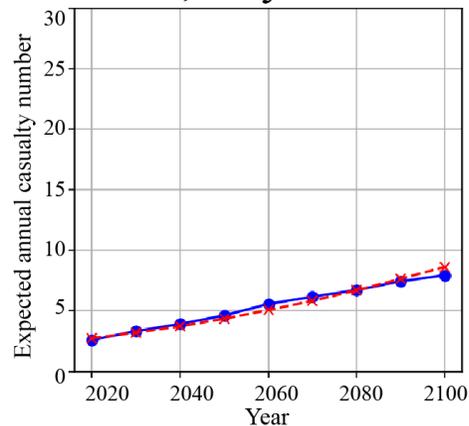
RCP4.5, LifeSim Model



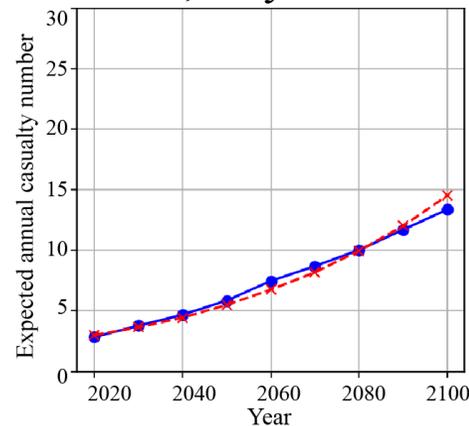
RCP8.5, LifeSim Model



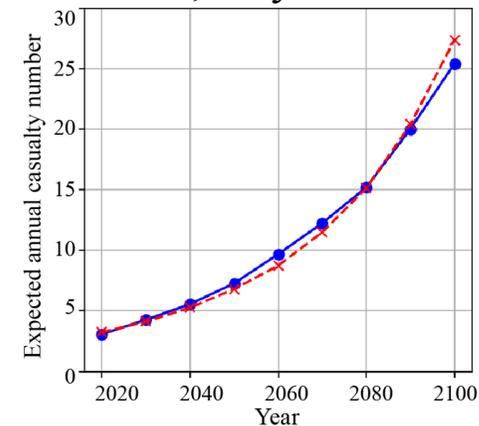
RCP2.6, Koyama Model



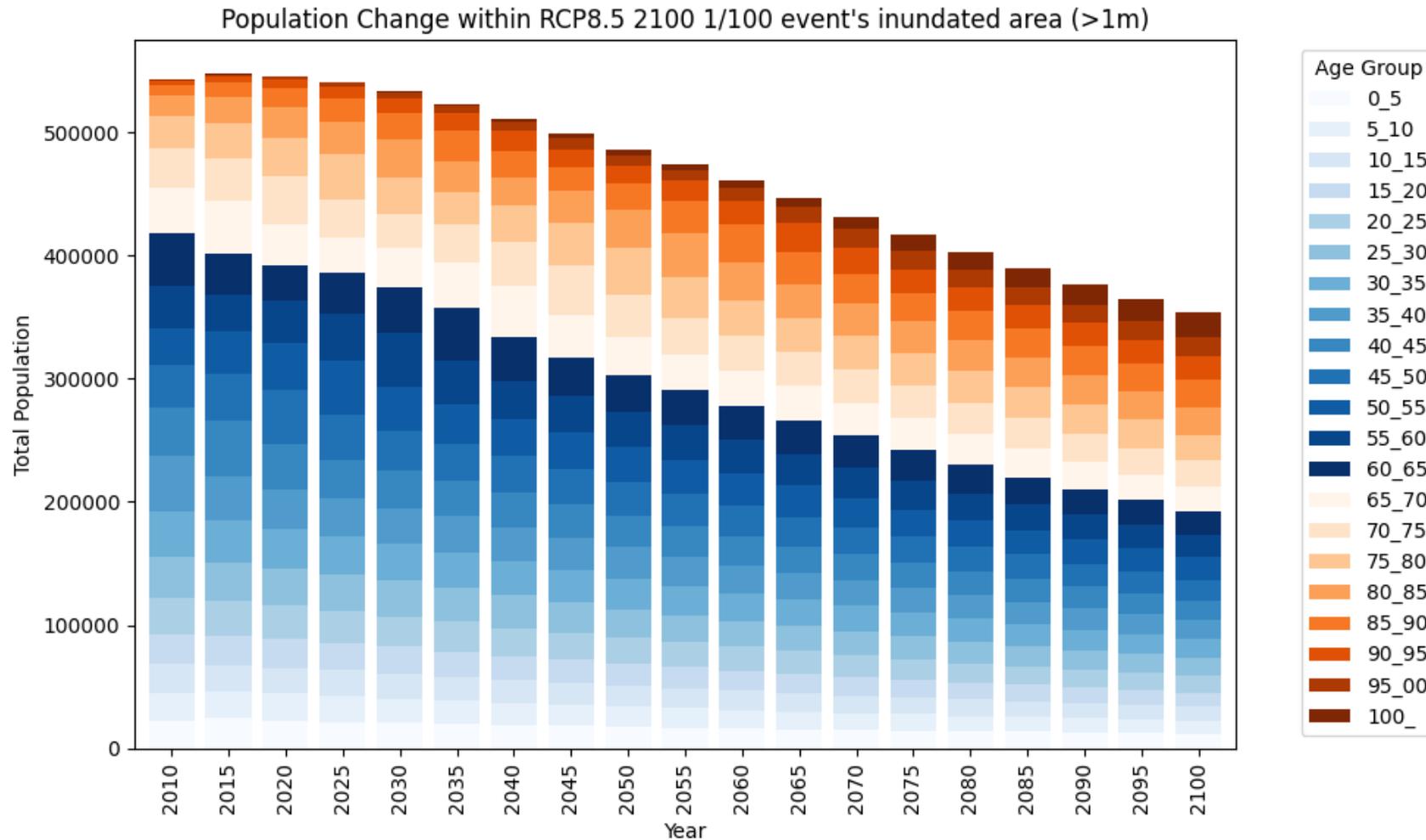
RCP4.5, Koyama Model



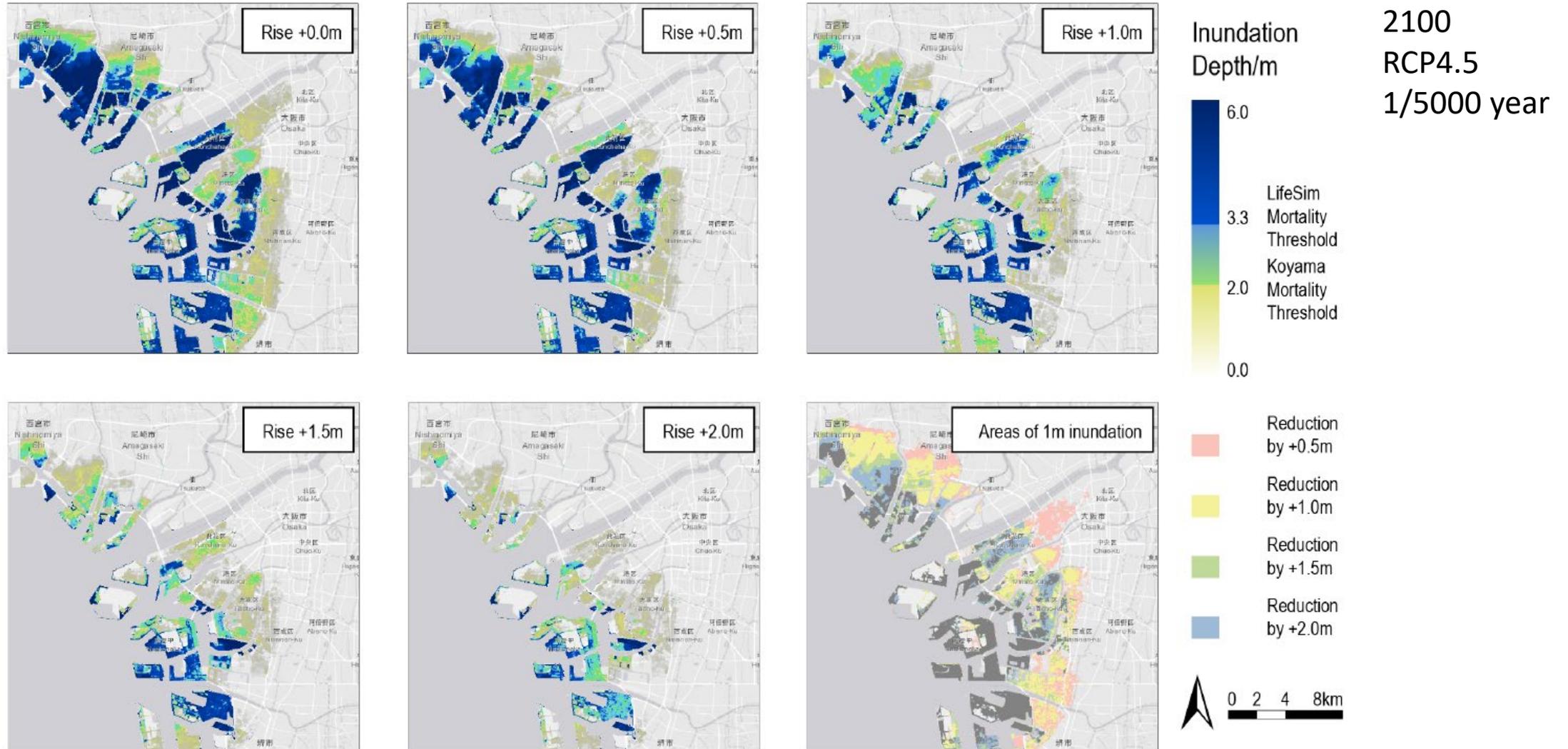
RCP8.5, Koyama Model



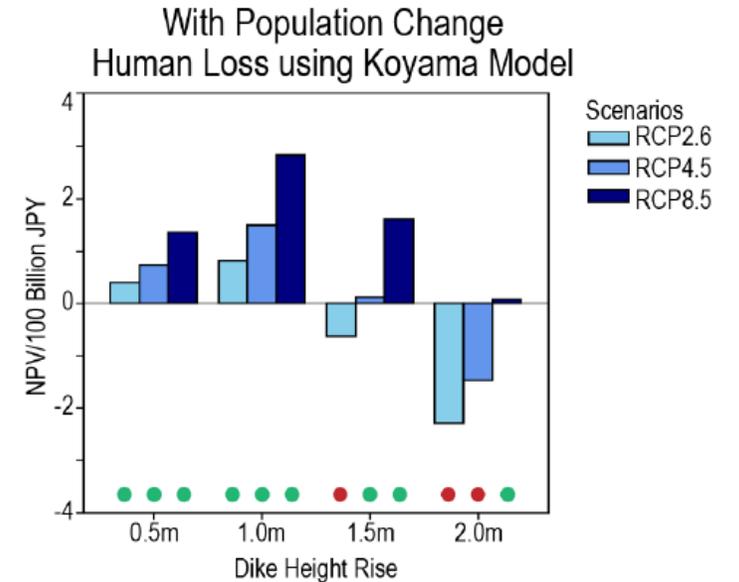
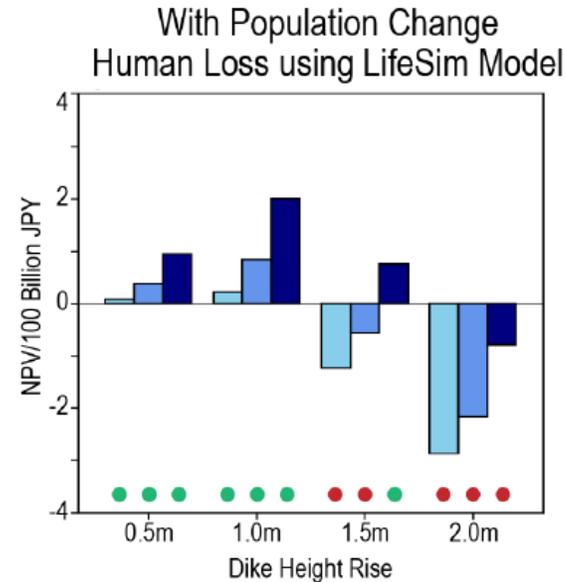
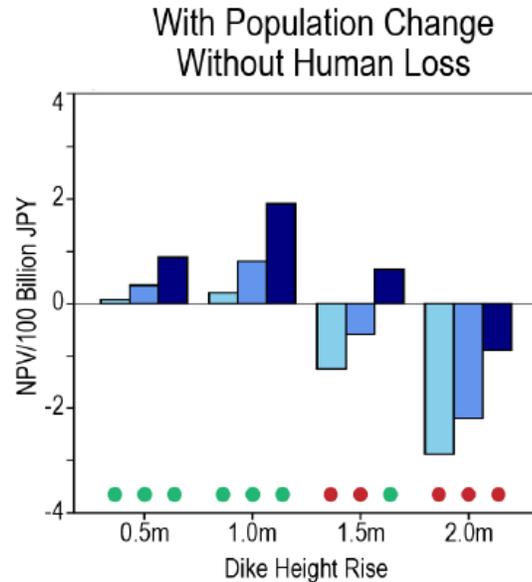
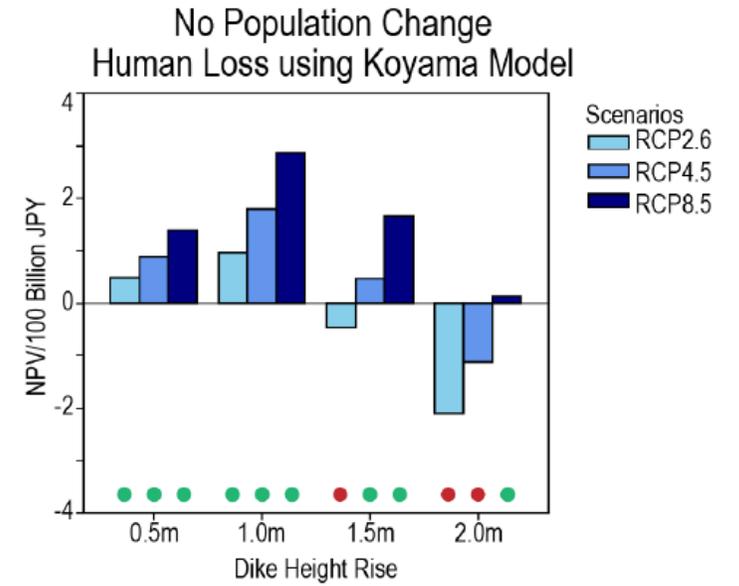
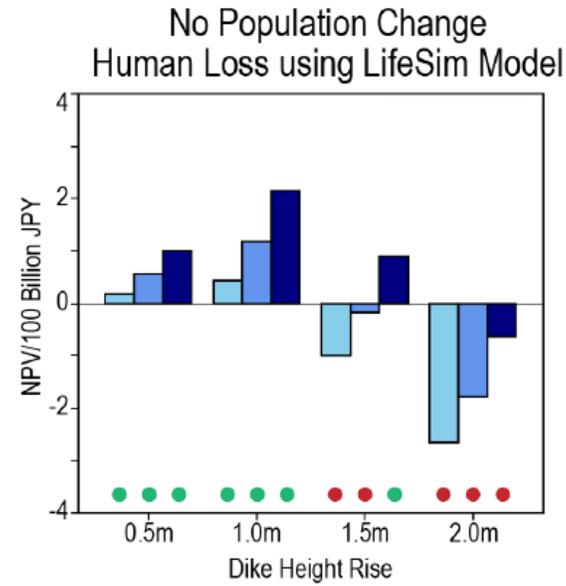
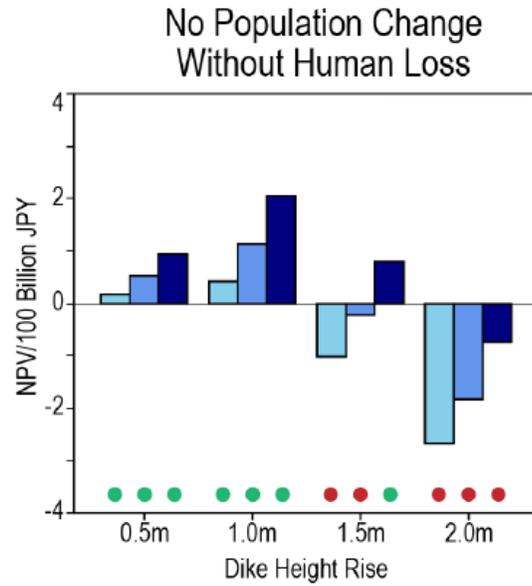
A possible reason of the causality estimation result



Flood risk reduction through raising dikes



Cost-Benefit Analysis



Summary

- Across all RCP scenarios, **economic losses from coastal flooding increased** even when population decline was taken into account.
- When **population decline was considered**, projected economic losses decreased to **approximately two-thirds** of the estimates that ignored population change.
- In contrast, **the projected number of fatalities remained nearly unchanged** between the population-decline and no-decline scenarios. This is likely due to the **increasing proportion of older adults**, who are more vulnerable to disasters.
- These results suggest that, under increasing storm-surge risk driven by climate change, economic damages may be mitigated by population decline, whereas human losses may increase to a similar extent as in the no-decline scenario because of heightened vulnerability associated with population aging.
- Raising the dike by 1.0 m is cost-effective across various scenarios in the target area.