NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE
Institute of Catastrophe Risk Management

Macro-Level Risk Assessment in Megacities

Summary

Following the rapid urban growth in recent years, exposure could be considered as the most dynamic component in risk assessment processes. Hence, estimation of spatiotemporal change of exposure is a critical and intricate task especially for megacities which are complex systems with high loss potentials. The conventional loss estimation approaches require a detailed inventory database of structures. Alternatively, macro-level socio-economic indicators are used, relying on regularly updated data. This study aims to project the natural disaster loss based on the spatiotemporal variability of exposure, assuming a direct relation between losses due to physical damages and business interruption, and the economic productivity of a region.

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Macro-Level Loss Estimation, *E(L)*:

Jaiswal and Wald (2011):

$$E(L) = \sum_{s} r(s) \times Eco.Exposure_{(intensity=s)}$$

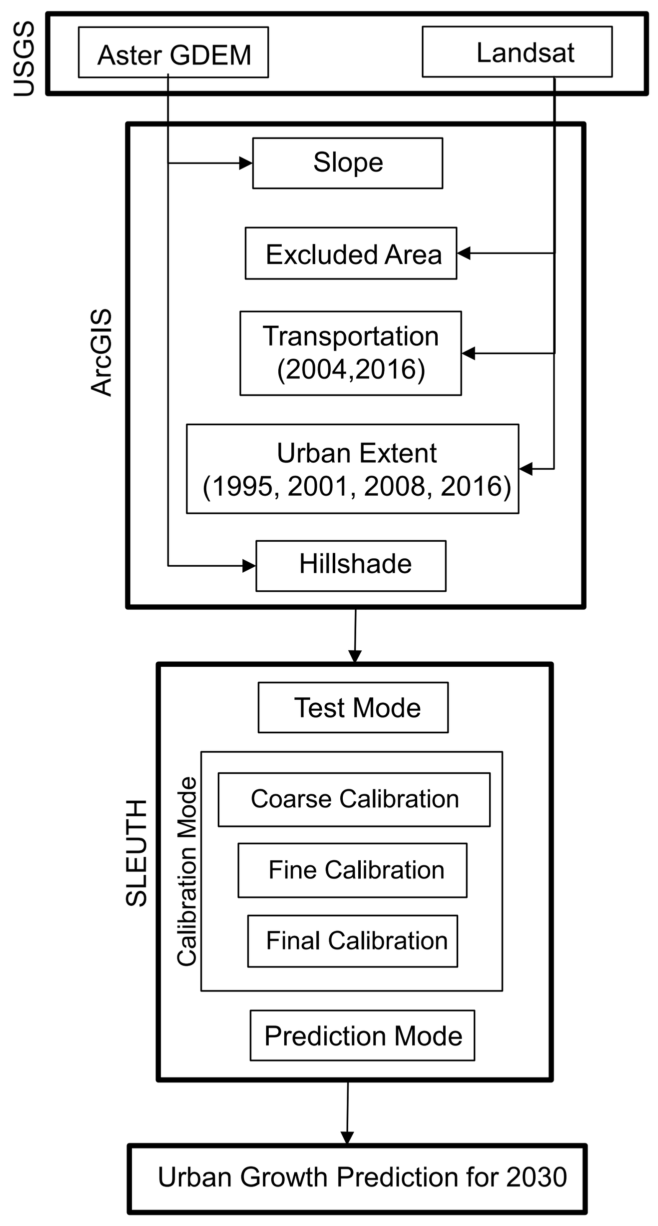
$$Eco.Exposure_{(intensity=s)} = \alpha_{region} \times Total\ GDP_{(region,intensity)}$$

$$r = \frac{Direct\ Economic\ Loss}{Total\ Economic\ Exposure} \qquad \alpha_{region} = \frac{Per\ Capita\ Wealth}{Per\ Capita\ GDP}$$

Exposure

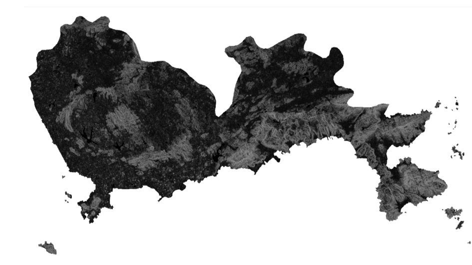
- Population
- GDP
- Urban Extent
- Capital Stock
- Wealth
- Road Density
- Night Time Light Data

SLEUTH Urban Growth Model for 2030

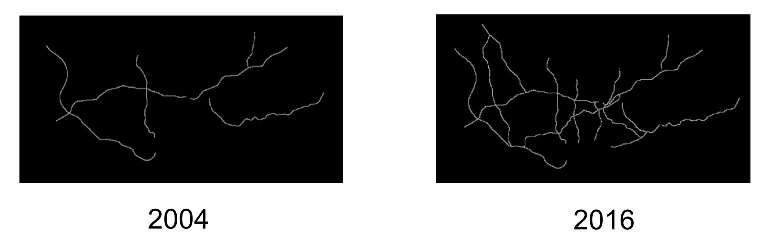


Inputs (Shenzhen, China):

1) Slope

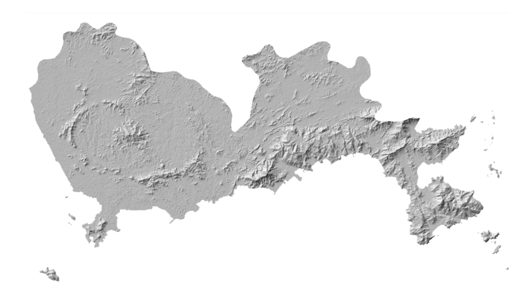


4) Transportation

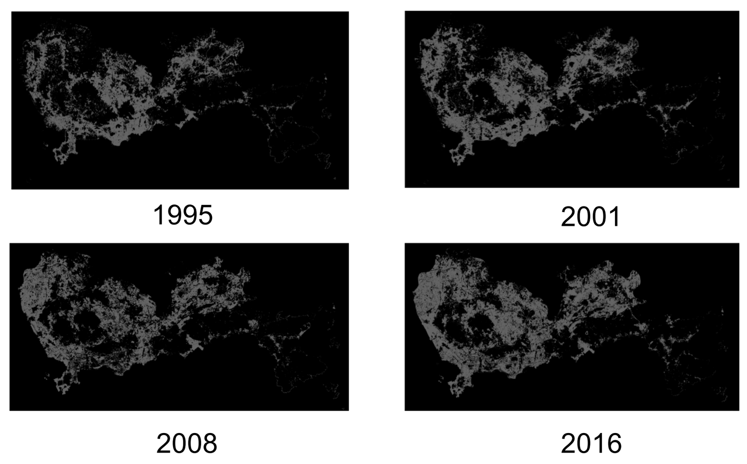


2) Excluded Area

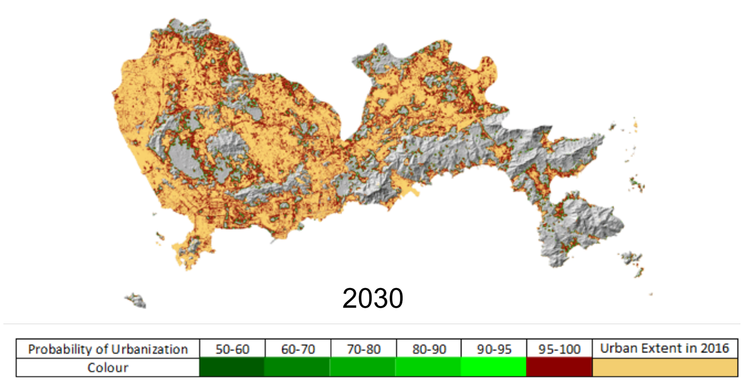
5) Hillshade



3) Urban Land



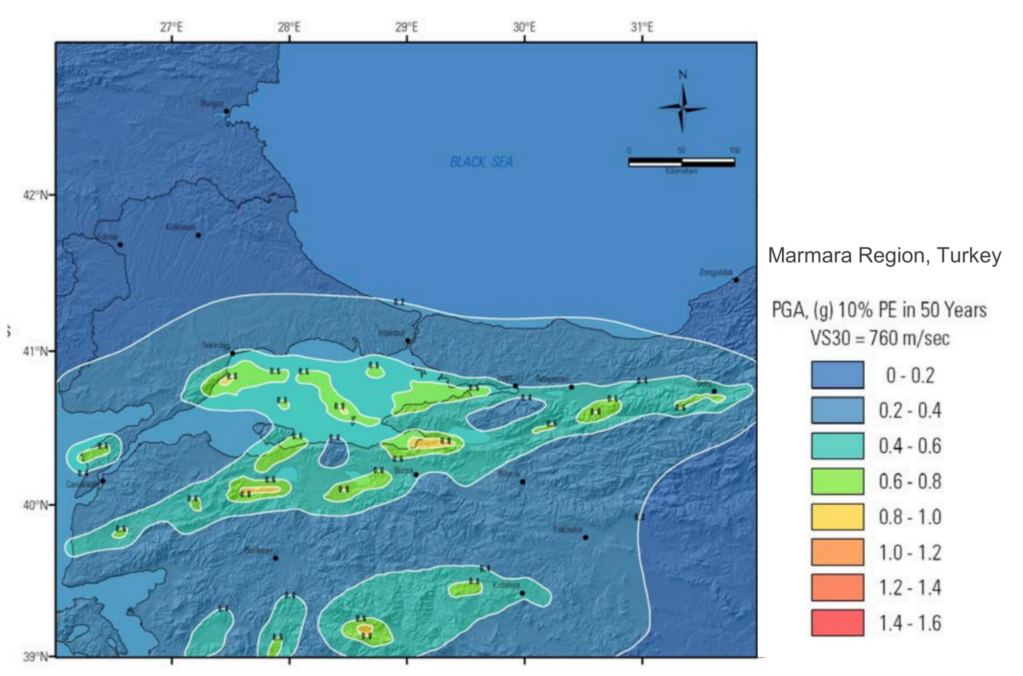
Output:



Hazard Analysis

1) Probabilistic Approach:

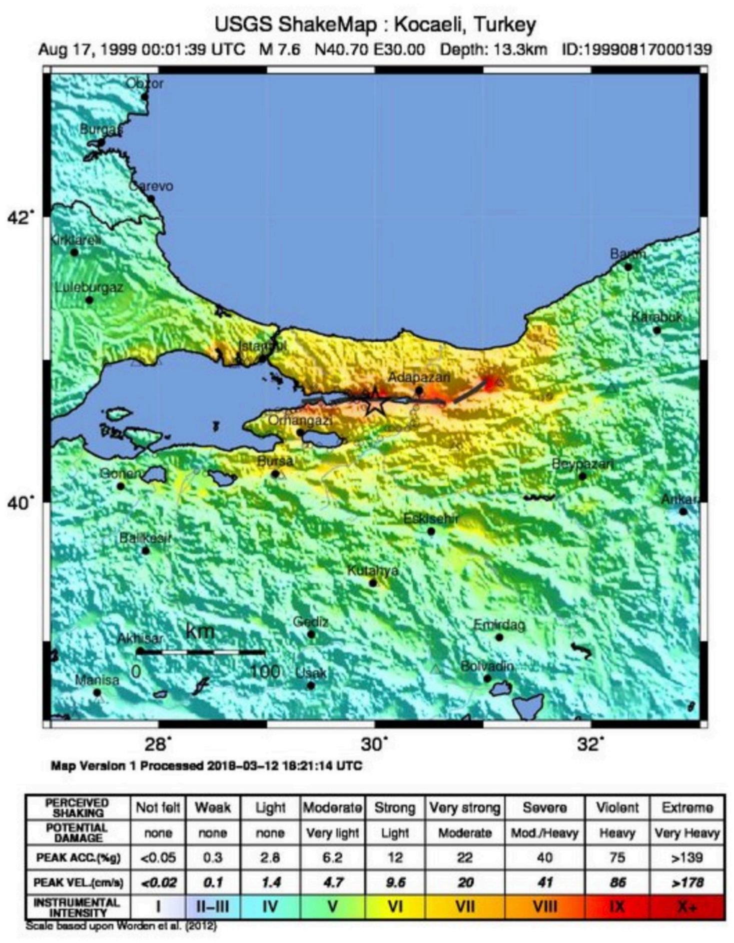
Hazard Map for Marmara Region Considering 10% Probability of Exceedance in 50 Years



- Hazard Maps and Hazard Curves can be used for Probabilistic Approach
- Historical Events or Scenario Events can be used for Deterministic Approach

2) Deterministic Approach:

Intensity Map for Kocaeli Earthquake (Mw 7.8), 1999.08.17



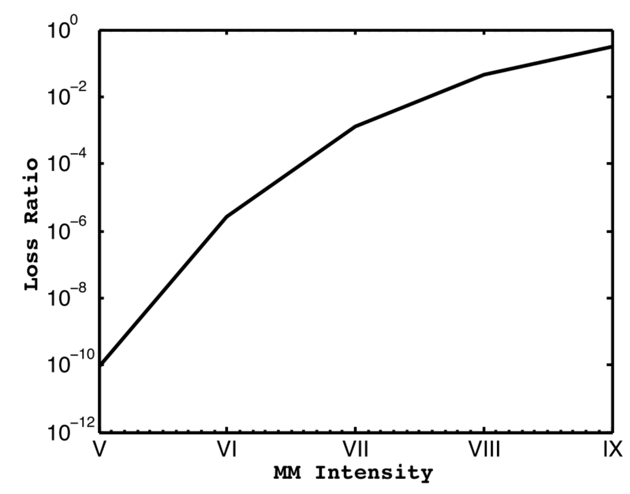
Loss Ratio, *r(s)*:

Jaiswal and Wald (2011):

$$r(s) = \phi\left[\frac{1}{\beta} ln\left(\frac{s}{\theta}\right)\right]$$

s: shaking intensity (MMI)
θ: mean of $ln(s)$
β: standard deviation of $ln(s)$
ϕ: standard normal cumulative distribution function

Country	θ	β
Albania	9.61	0.10
Australia	8.88	0.10
Chile	9.73	0.10
Italy	9.03	0.10
Japan	10.29	0.10
Nigeria	8.64	0.10
Trinidad and Tobago	9.65	0.11
Turkey	9.46	0.10
United States (without California)	11.51	0.15
California	9.60	0.10



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References:
Jaiswal, K., & Wald, D. J. (2013). Estimating economic losses from earthquakes using an empirical approach. Earthquake Spectra, 29(1), 309–324.
Kalkan E., Gulkan, P., Yilmaz, N. and Celebi, M. (2009). “Re-Examination of Probabilistic Seismic Hazard in the Marmara Sea Region”, Bulletin of Seismological Society of America, 99(4): 2127–2146.
USGS ShakeMap, Retrieved from https://earthquake.usgs.gov/earthquakes/eventpage/usp0009d4z#shakemap