

Modelling the Global Seismic Risk of Buildings and Infrastructure under a Changing Environment

GLOBAL EARTHQUAKE MODEL (GEM) FOUNDATION

Helen Crowley, Secretary General

PAVIA, OCTOBER 2023



working together
to assess risk

GEM
GLOBAL EARTHQUAKE MODEL

OO
OPENQUAKE

About GEM Foundation

Non-profit scientific NGO, founded in 2009

Global, public-private partnership

We develop open software, tools and data for use in earthquake hazard and risk assessment worldwide, and work together with local governments and institutions to promote their use in DRR applications.

Our Vision

For a world that is resilient to earthquakes and other natural hazards

www.globalquakemodel.org



Our Supporters

Public Governors



Private Governors



Advisor Sponsors



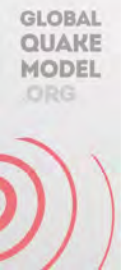
Associate Partners



Project Partners



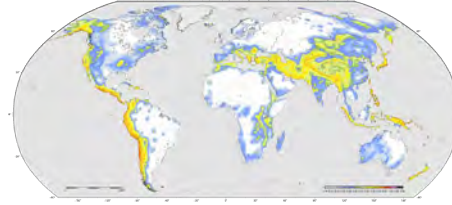
Product Distribution Partners



Our Methodology

We collect and process data worldwide, related to the main components of seismic risk.

GEM has a fully functional global model of components used to assess earthquake impacts worldwide, leading to a number of flagship products.

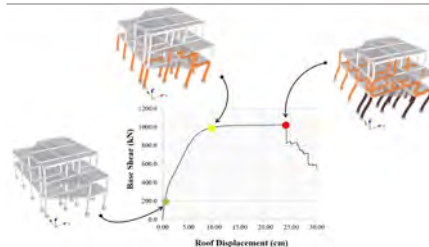


Hazard

The seismic potential at any location

Exposure

The distribution and characteristics of built environment



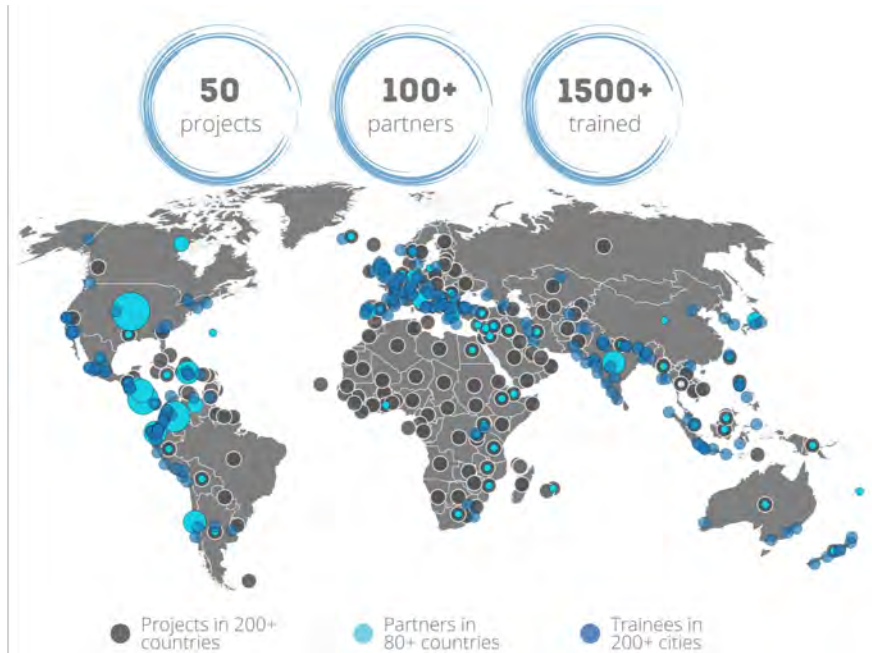
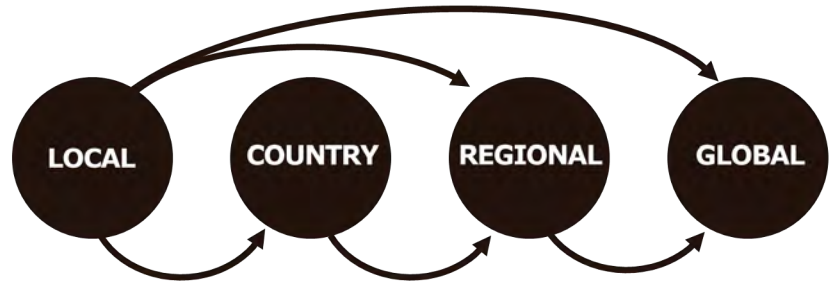
Vulnerability

The expected damage given the hazard



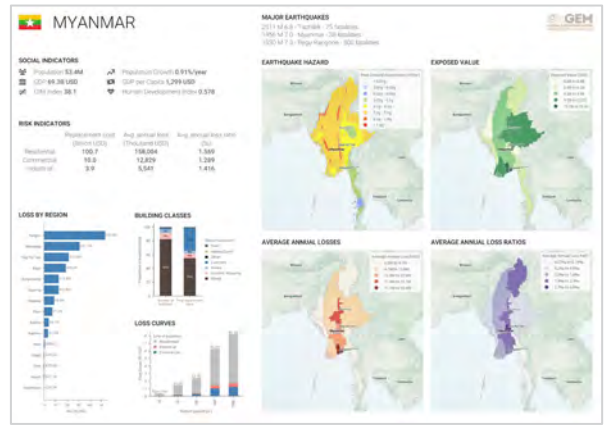
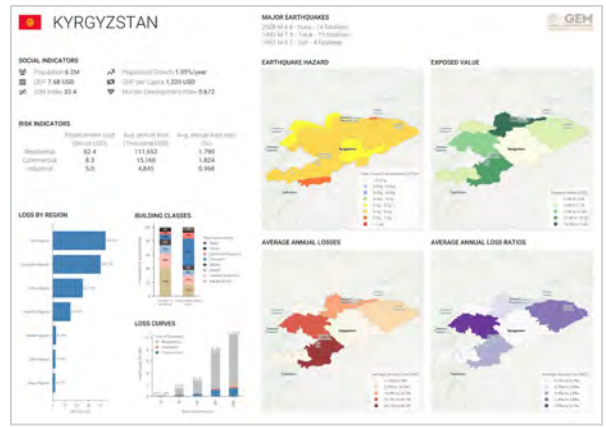
Collaboration Framework

- Built upon collaborations and partnerships
- Multi-level approach, linking local through to global scale
- Guided by GEM Principles:
 - Collaboration
 - Credibility
 - Openness
 - Public-good



GEM's Projects Funded by ADB

- Developing a Disaster Risk Transfer Facility in the Central Asia Regional Economic Cooperation (CAREC) Region
- Development of an Earthquake Risk Model for Myanmar (Contribution to ADB TA 9307-MYA: Strengthening Climate and Disaster Resilience of Myanmar Communities)
- Strengthening capacity on disaster risk assessment, reduction and transfer instruments in Mongolia





Global Hazard Map



OpenQuake Engine



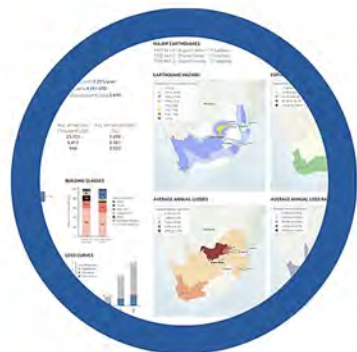
Global Risk Map



Global Exposure Model



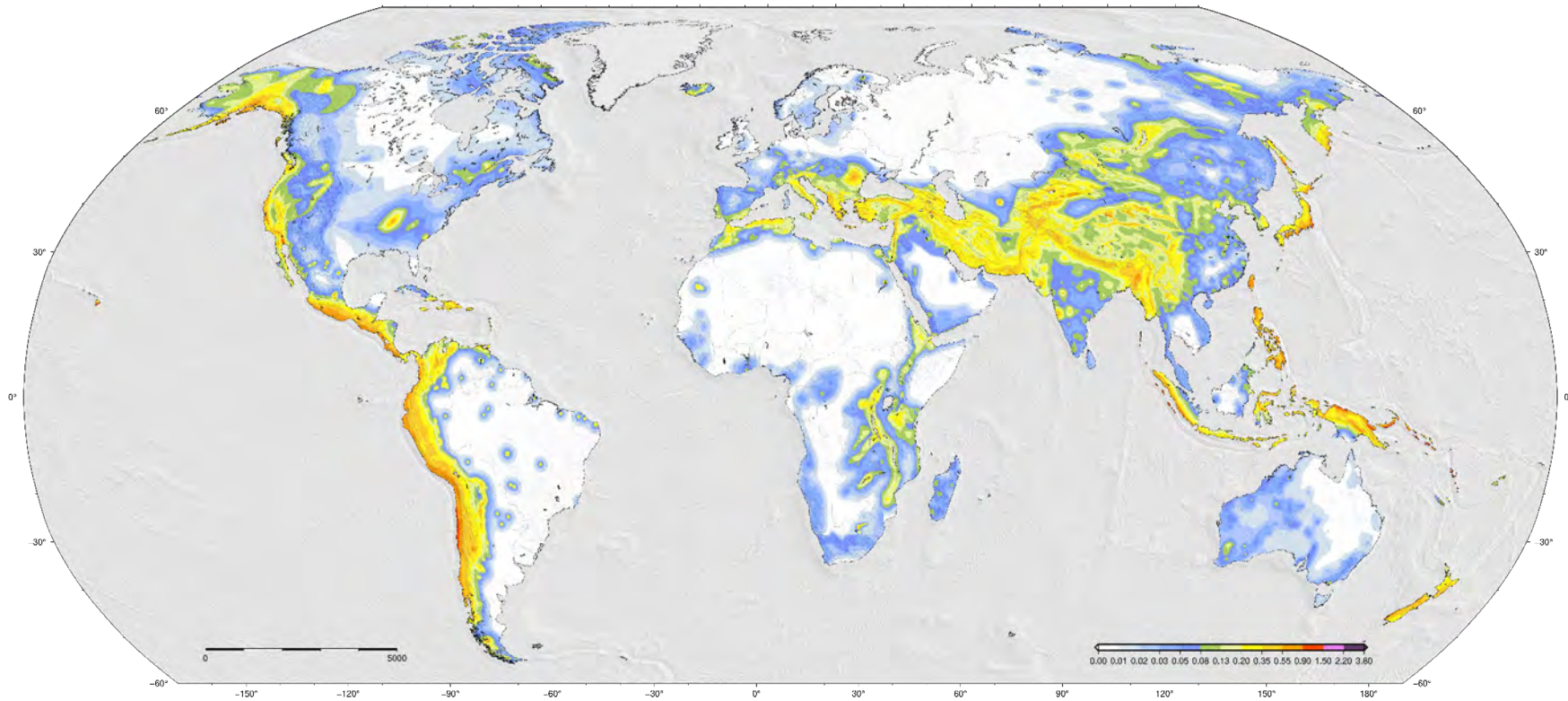
Global Vulnerability Model



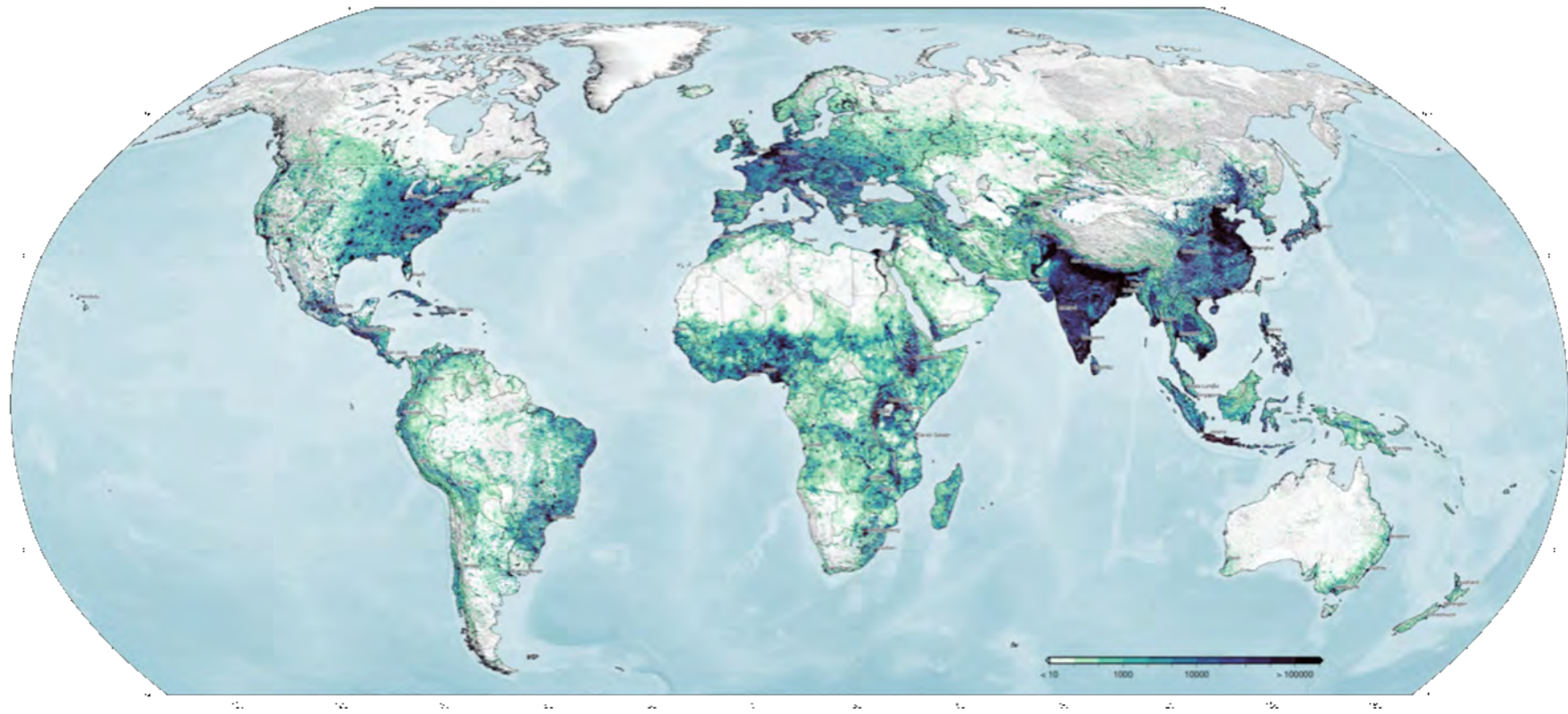
Risk Profiles



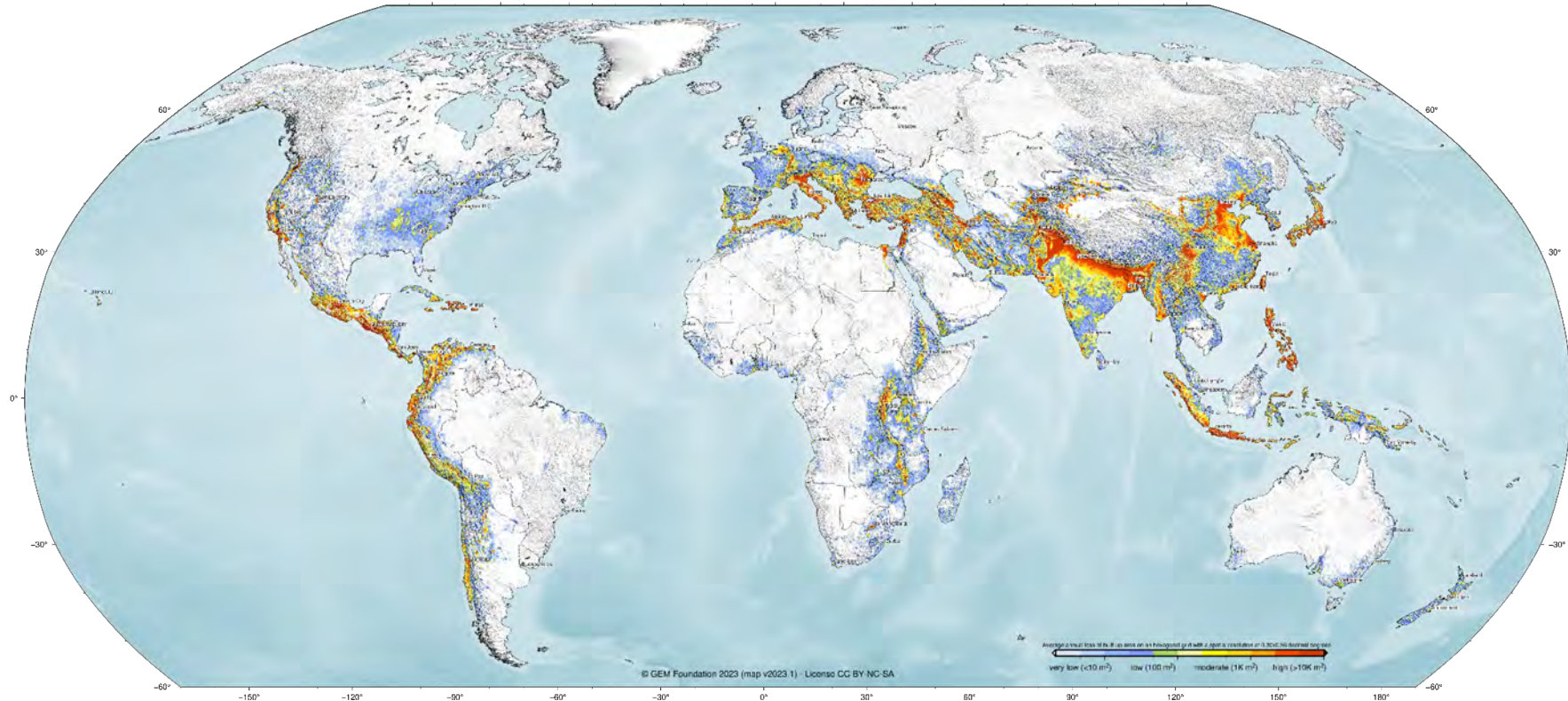
Global Seismic Hazard Maps (v2018, v2023)



Global Exposure Maps (v2018, v2023)



Global Seismic Risk Maps (v2018, v2023)

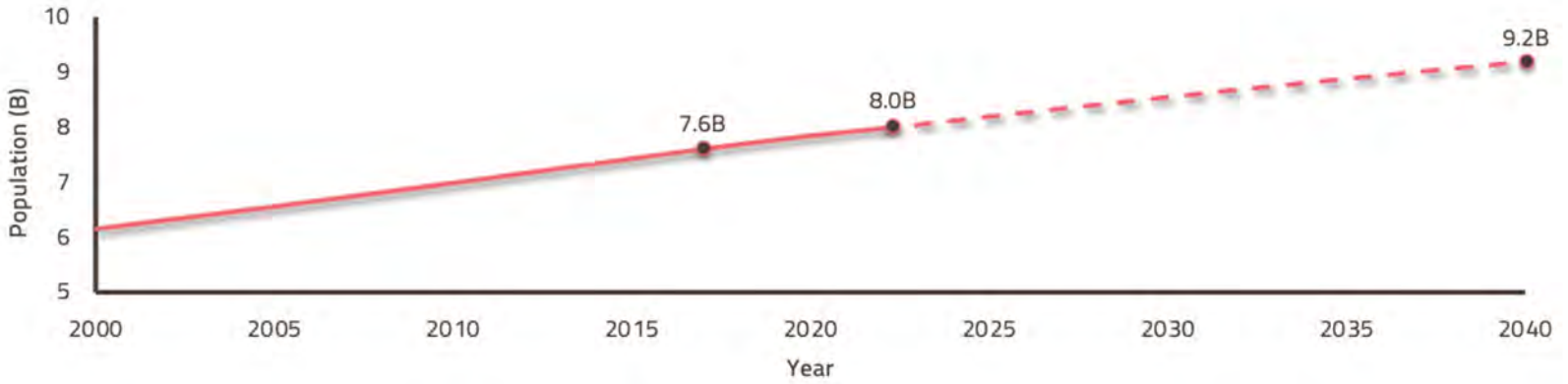


© GEM Foundation 2023 (map v2023 1) - License CC BY-NC-SA

Average annual loss of the world in billions of USD with a population of 8 billion in 2023
Legend: very low (<10 m²), low (100 m²), moderate (1K m²), high (>10K m²)



Changes in Global Exposure



+ 375 million people



Equivalent to the population of United States + Canada

+ 98 million dwellings



Equivalent to all dwellings in Indonesia + South Korea

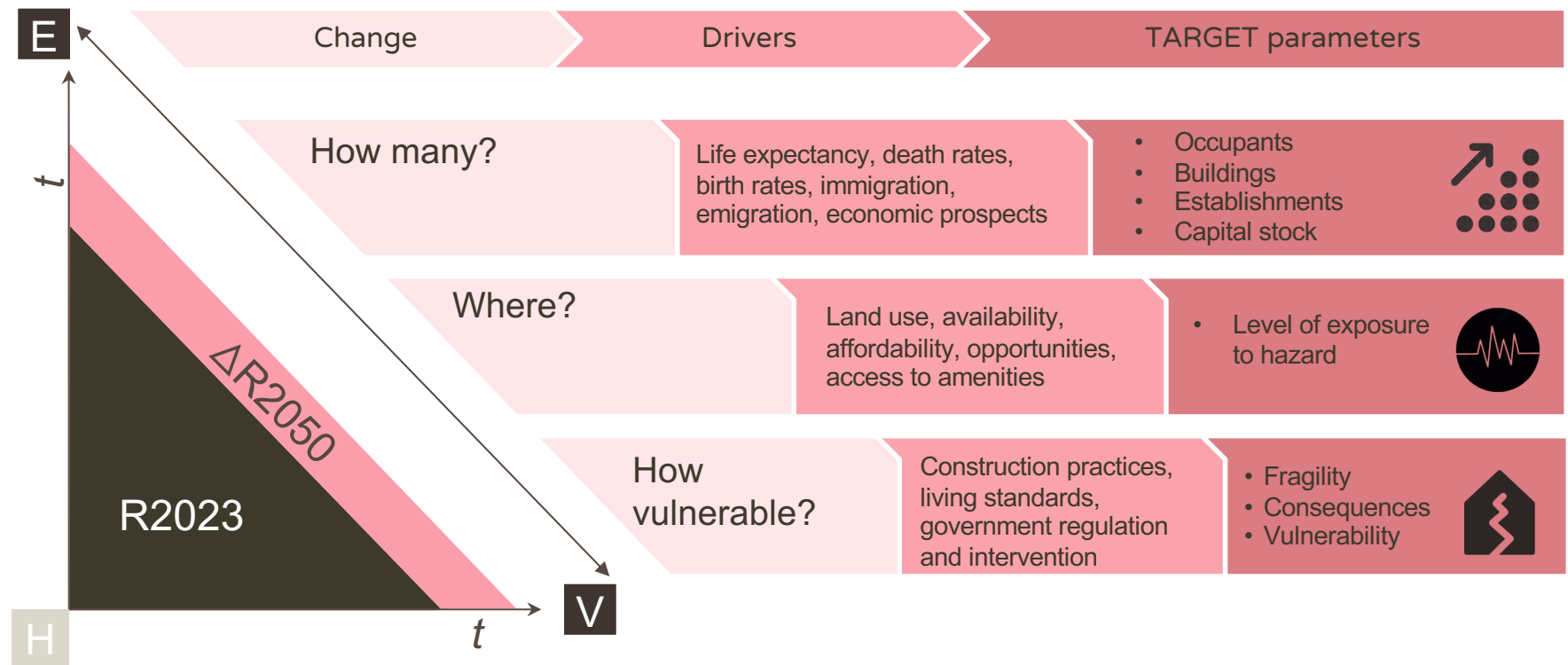
+ 73 million buildings



Equivalent to all buildings in Brazil + Argentina



Risk Under a Changing Environment





FORCE: Forecasting and Communicating Earthquake Hazard and Risk



Knowledge

State-of-the-art on seismic hazard and risk modelling to forecast future risk

Training

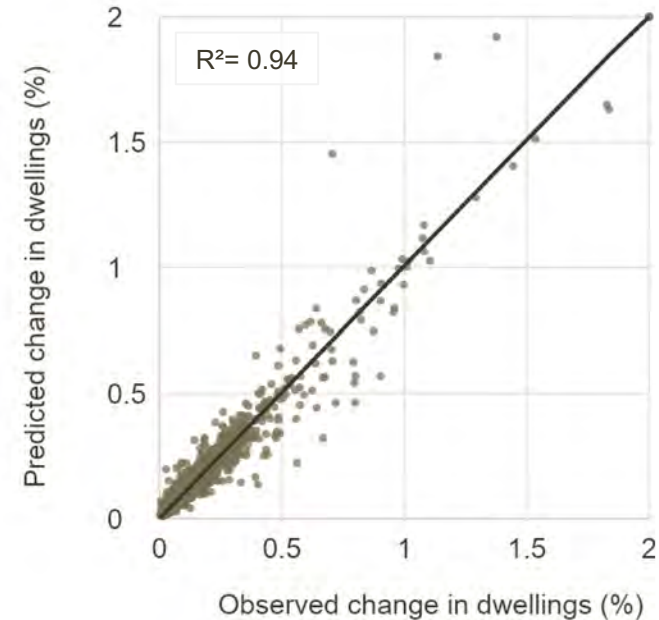
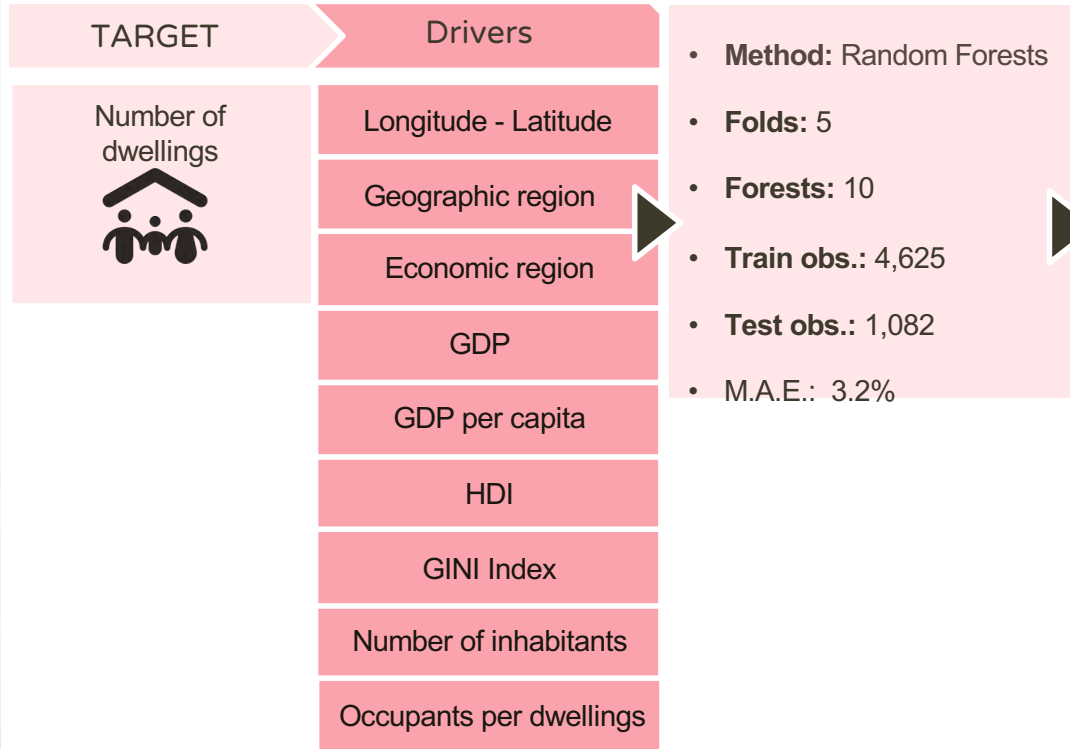
Strengthening local capacities and consolidating a technical community network

Communication

Usable information for stakeholders and decision-making authorities



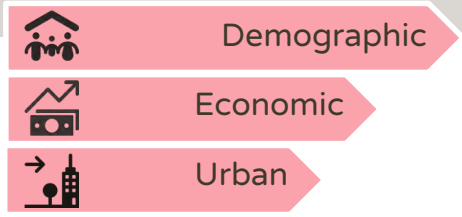
Forecasting Exposure using Machine Learning



Narratives for Forecasting Exposure

There are frameworks already in place that facilitate **the integrated analysis of future development** (on the front of climate change):

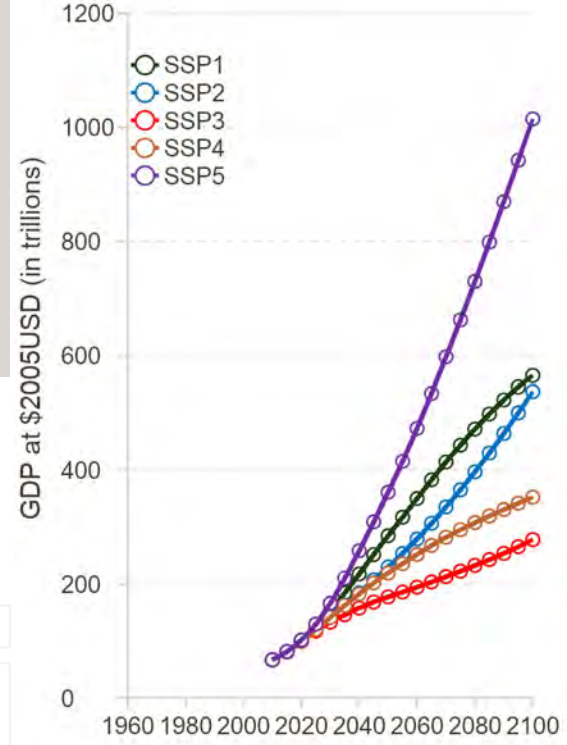
The **Shared Socio-Economic Pathways (SSPs)** cover global development in different dimensions, including:



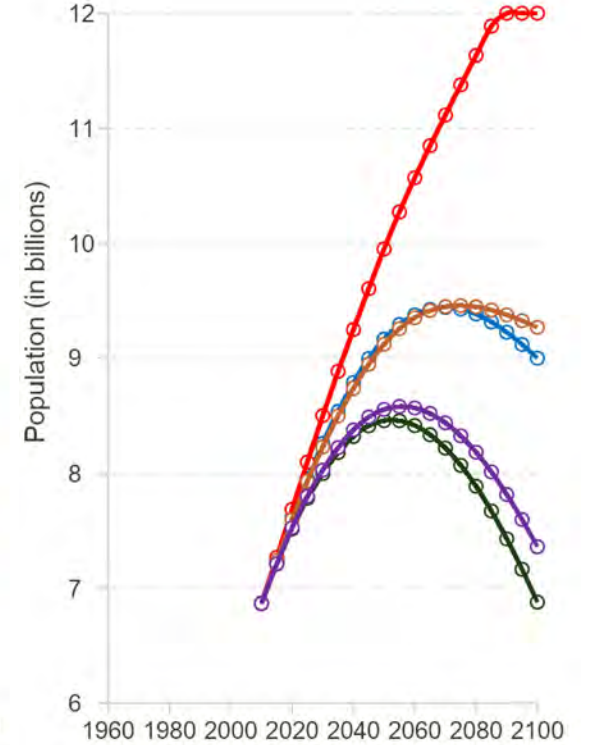
SSP Public Database (Version 2.0) <https://tntcat.iiasa.ac.at/SspDb>

Keywan et al. *The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview*, Global Environmental Change, Volume 42, Pages 153-168, 2017, ISSN 0959-3780, DOI:110.1016/j.gloenvcha.2016.05.009

Forecast of global GDP per SSP



Forecast of global population per SSP



Forecasting Scenarios for Risk Assessment

Forecasting Scenario 1:

SSP2	(V.1)
<p>Demographic growth: <i>mean fertility, life expectancy estimates</i></p> <p>Development: <i>historical GDP, HDI trends</i></p>	<p>Vulnerability <i>Continue to implement current design regulations</i></p>



Forecasting Scenario 2:

SSP2	(V.2)
<p>Demographic growth: <i>mean fertility, life expectancy estimates</i></p> <p>Development: <i>historical GDP, HDI trends</i></p>	<p>Vulnerability <i>Better implementation of design regulations</i></p>



Scenario SSP2 2020

Number of exposed dwellings (0.25-degree)



0.016M 0.16M 1.6M

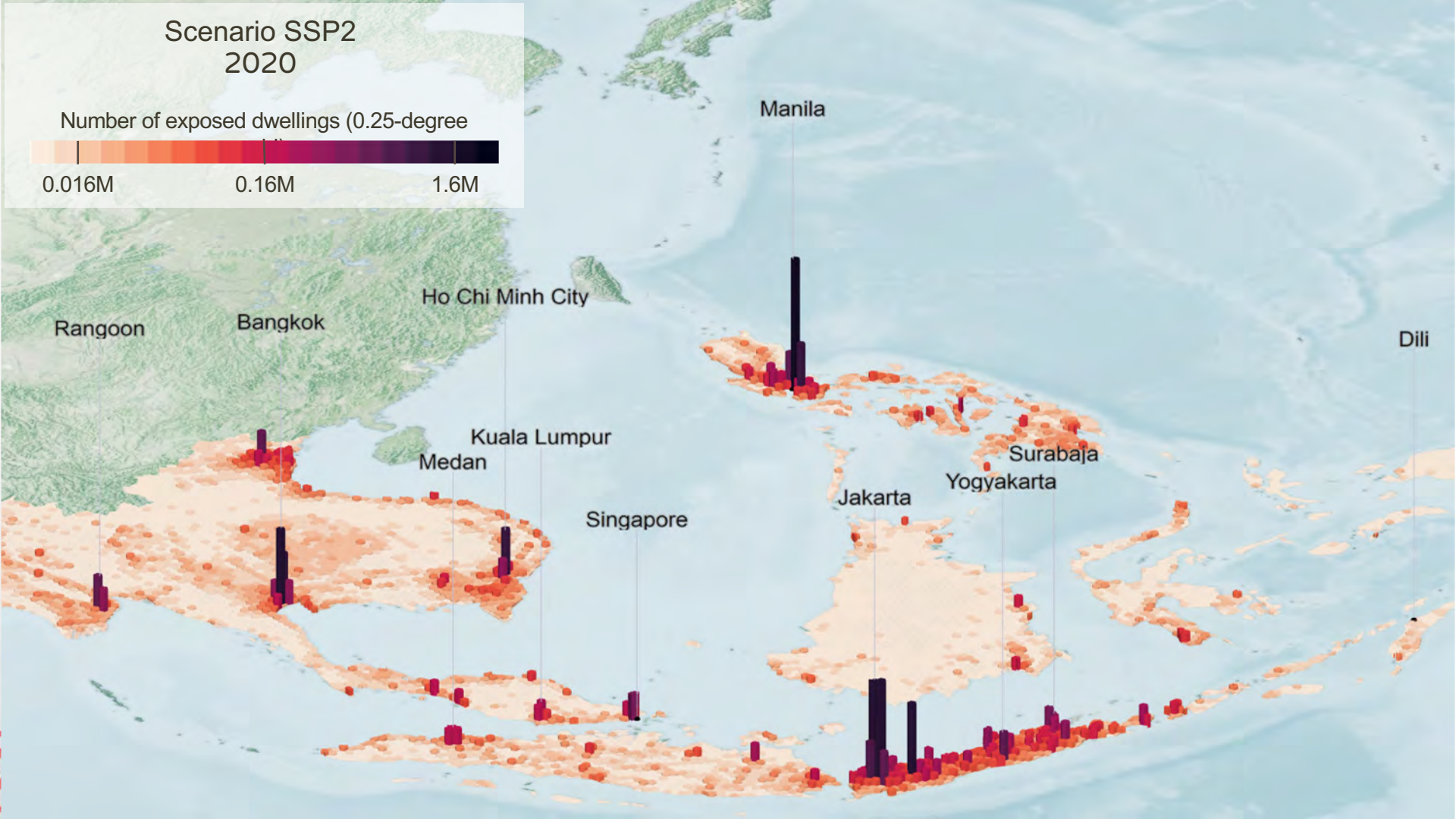


Scenario SSP2 2020

Number of exposed dwellings (0.25-degree

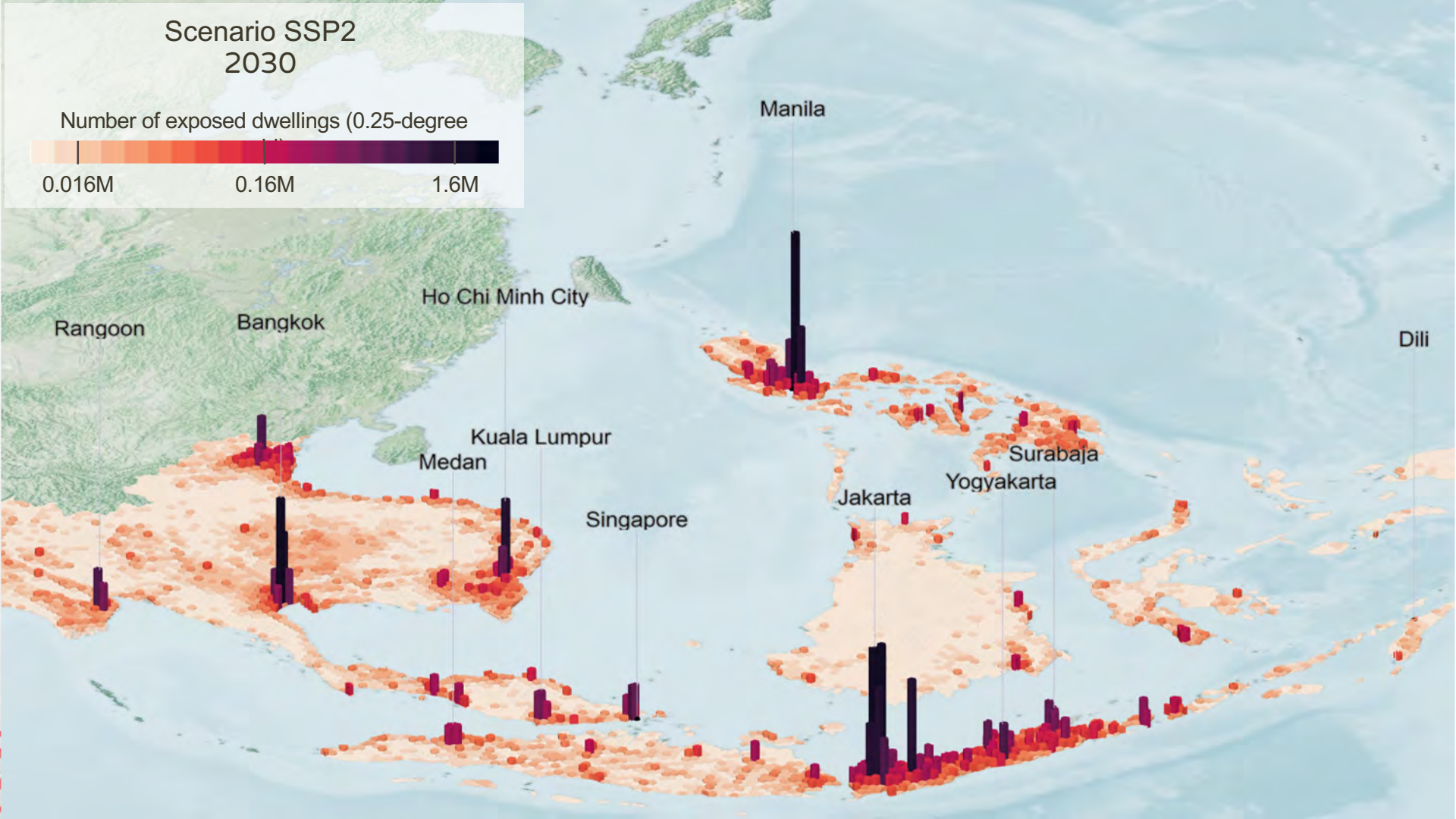
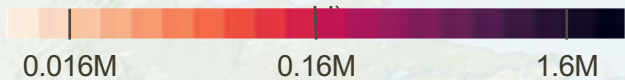


0.016M 0.16M 1.6M



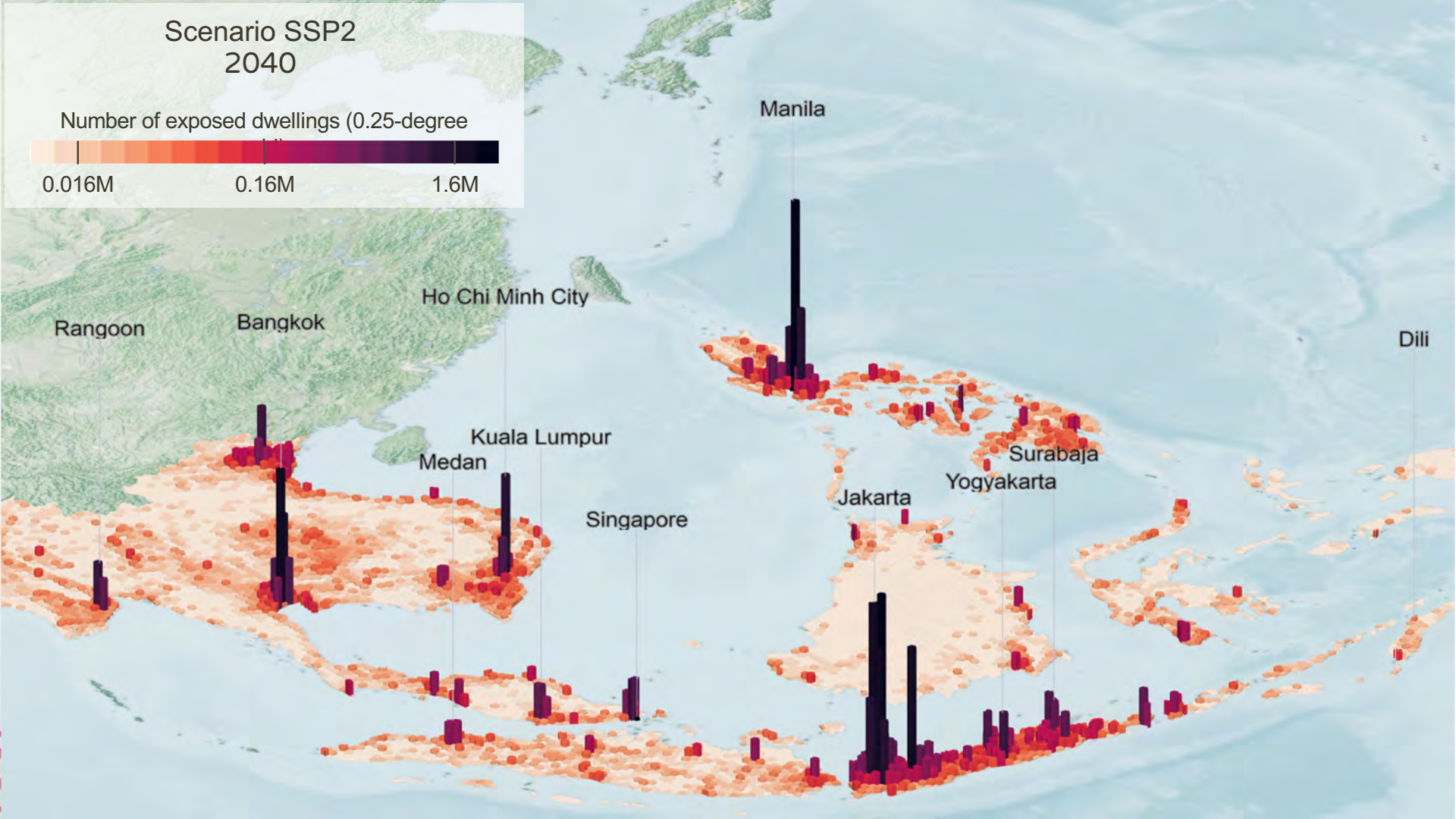
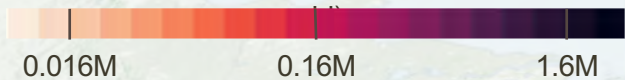
Scenario SSP2 2030

Number of exposed dwellings (0.25-degree



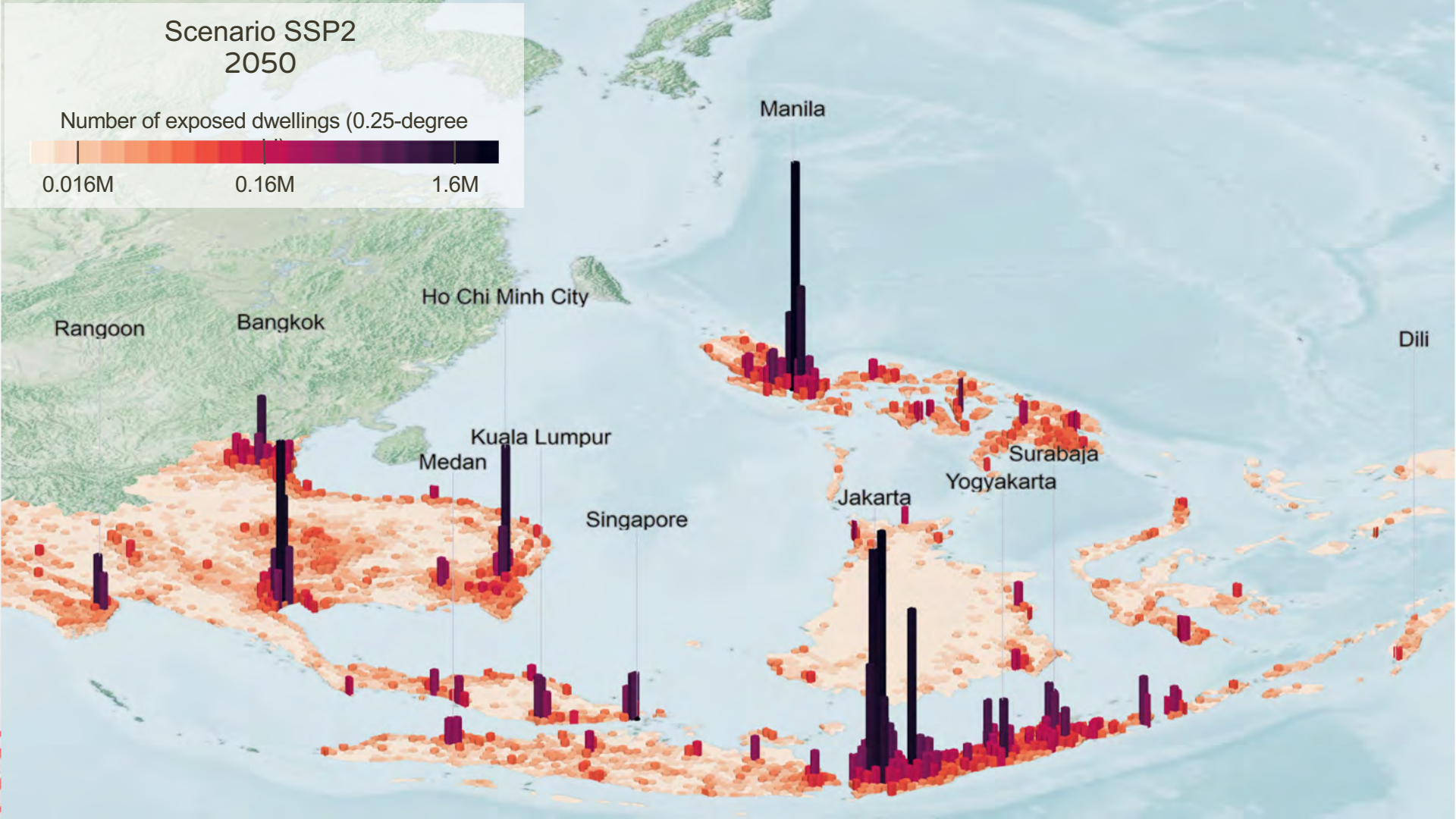
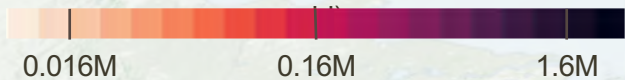
Scenario SSP2 2040

Number of exposed dwellings (0.25-degree



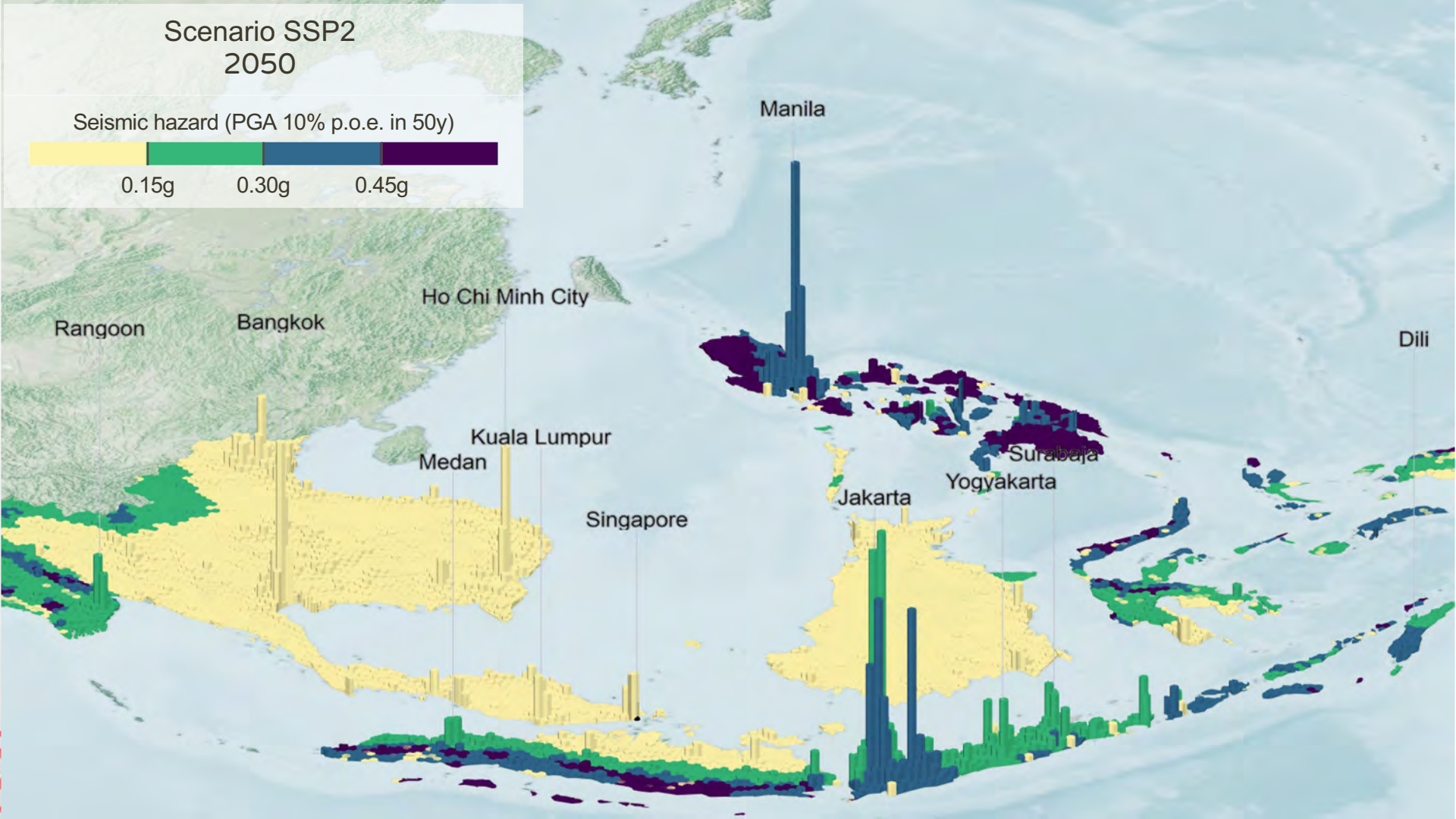
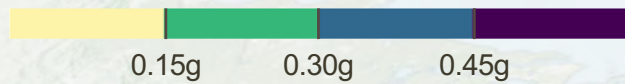
Scenario SSP2 2050

Number of exposed dwellings (0.25-degree



Scenario SSP2 2050

Seismic hazard (PGA 10% p.o.e. in 50y)



Future Developments Towards GEM's Vision

- Produce global forecasts of building exposure and risk for 2030, 2040, 2050 under different SSPs and vulnerability scenarios
- Encourage the use of these models with other natural hazards communities (e.g. tsunami, sea level rise, flooding..), expanding to include additional hazard-specific attributes.
- Move beyond residential, commercial and industrial buildings to model global exposure of public buildings and infrastructure (e.g. hospitals, schools, road/rail networks) - current and forecasted.
- Within the field of hazard assessment:
 - Assess the global seismic hazard for **the next** 50 years
 - Identify areas of the world that are most likely to experience earthquake induced liquefaction and landslides
 - Assess how climate change / sea level rise can affect liquefaction occurrence
 - ...



Questions?

Please attribute to the GEM Foundation with a link to:

<https://www.globalquakemodel.org>



Except where otherwise noted, this work is licensed under a
Creative Commons Attribution-NonCommercial-NoDerivatives 4.0
International License (CC BY-NC-ND 4.0)

<https://creativecommons.org/licenses/by-nc-nd/4.0/>

