



FUTURE EXPOSURE AND RISK TO NATURAL HAZARDS

Where are we heading?

ALEJANDRO CALDERON

Bergamo, June 14th, 2023



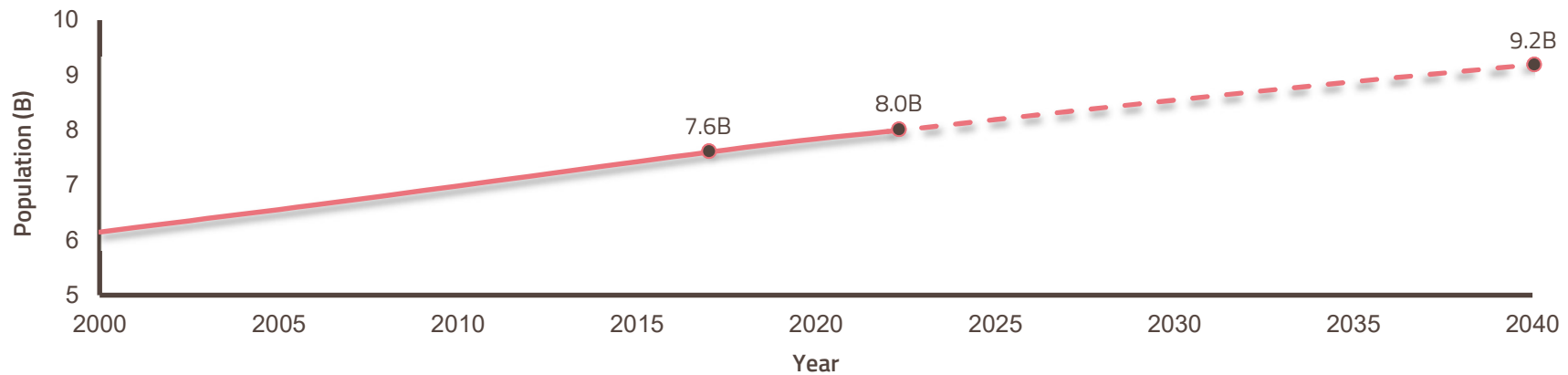
working together
to assess risk

GEM
GLOBAL EARTHQUAKE MODEL

OO
OPENQUAKE

SINCE 2018, A LOT HAS HAPPENED

2



+ 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

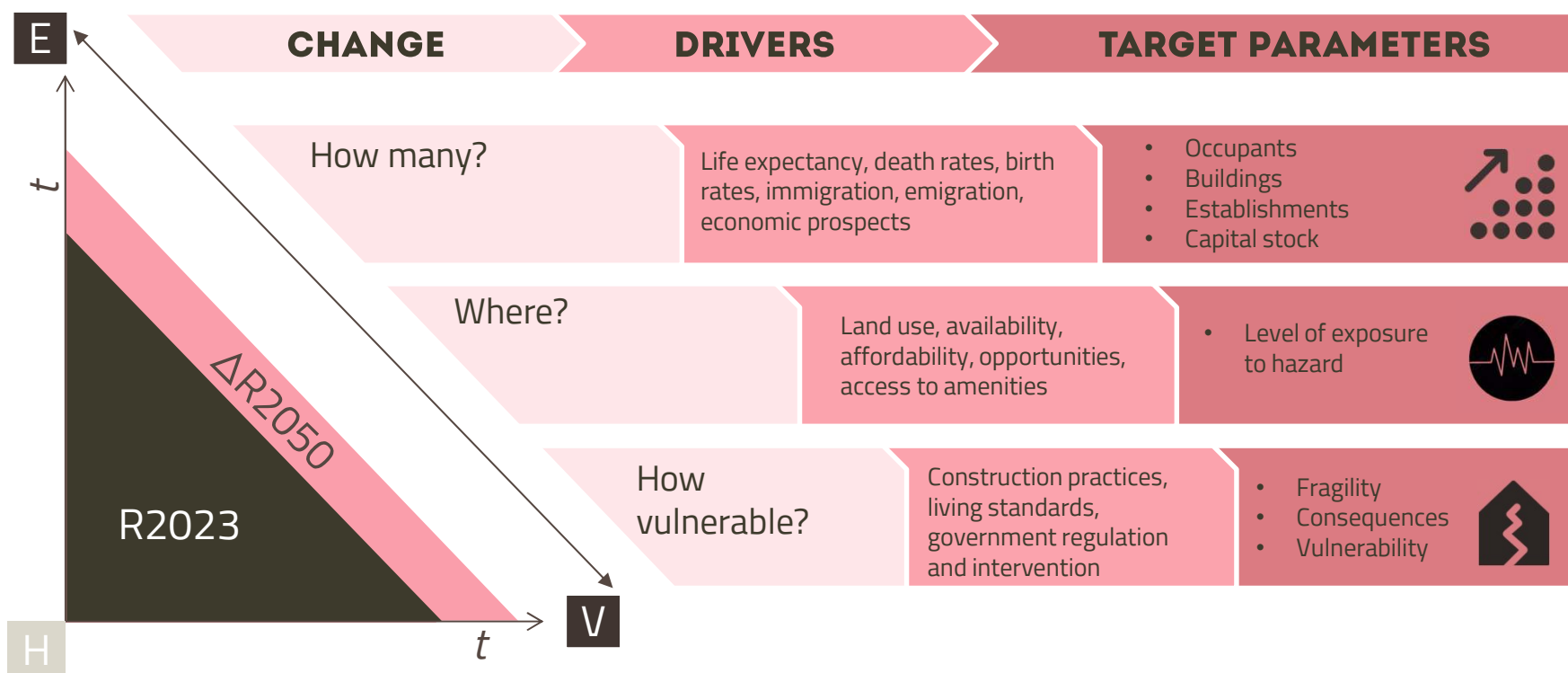
GLOBAL QUAKE MODEL .ORG

GEM

DISASTER MANAGEMENT STRATEGIES

	Hazards	Main strategy	Time scale
NETHERLANDS government.nl/topics/delta-programme		Safeguard dams, storm surge barriers, floodgates and locks protecting the population from floods and sea level rise	50-year and 100-year term planning
JAPAN bosai-jp.org/en/solution/category		Minimizing loss of life from earthquakes, tsunamis, typhoons, floods and volcanic eruptions	Decades-long plan scale
CUBA Sims and Vogelmann (2002)		Relocating at-risk populations , building resistant housing + infrastructure, developing resilient agricultural systems	50-year and 100-year horizon
BANGLADESH National Adaptation Plan of Bangladesh 2023-2050		Limit saltwater intrusion, build storm shelters, relocate vulnerable populations , enhance early warning systems	30-year horizon
AUSTRALIA dceew.gov.au/climate-change/policy/environment		Prescribed burning, fire-resistant structures , agricultural diversification and comprehensive water conservation strategies	Decades-long plan scale

WHAT WE NEED TO ACCOUNT FOR



WHAT WE HAVE TRIED SO FAR

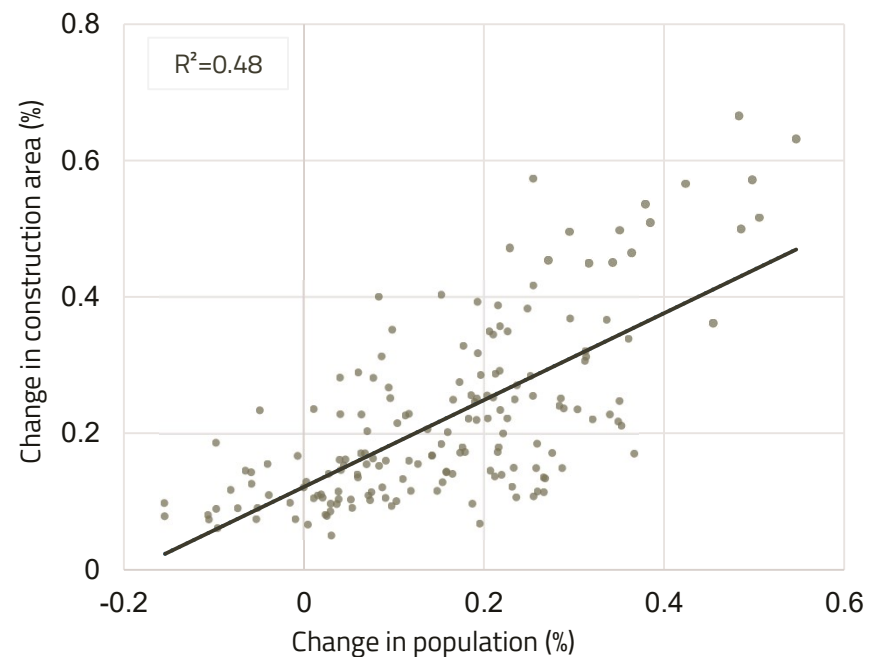
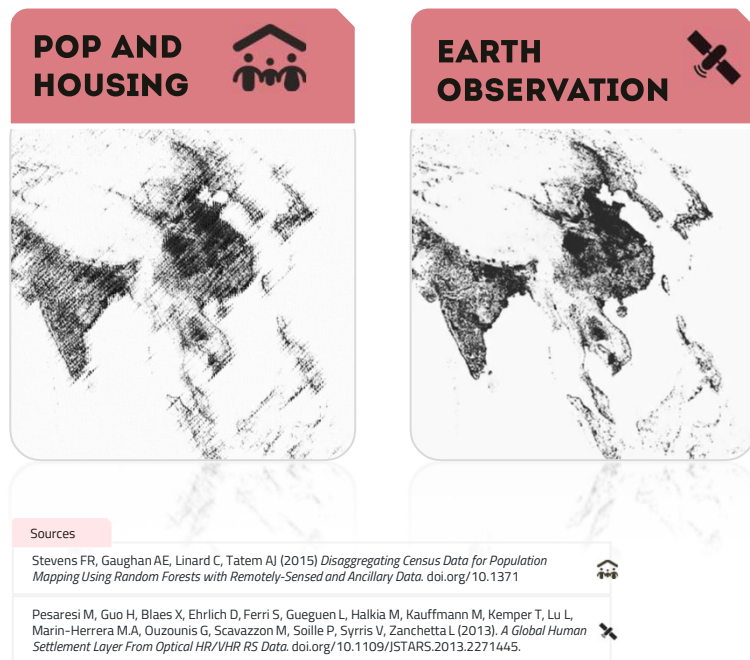
5

Establish a relationship between **population** and **construction** by observing changes at a country level



Calderon A, Silva V (2020)

Forecast of Risk within the Context of the SFDRR: Study Cases in Central America and the Caribbean



WHAT WE HAVE TRIED SO FAR

6

Establish a relationship between **economic growth** and **construction** by observing changes on a regional scale



World Bank, GEM Foundation (2021)

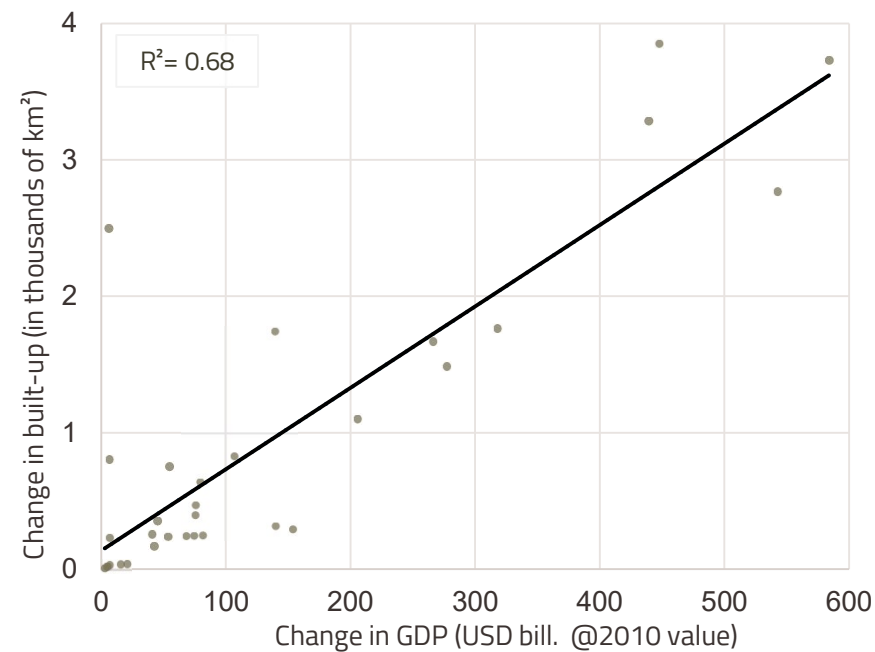
Regional risk assessment of the European Union Member States



Sources

OECD Data (2014). Real GDP long-term forecast 2015 - 2060. Taken from the database *Long-term baseline projections - No.95 (2014)*.

Pesaresi M, Guo H, Blaes X, Ehrlich D, Ferri S, Gueguen L, Halkia M, Kauffmann M, Kemper T, Lu L, Marin-Herrera M.A, Ouzounis G, Scavazzon M, Soille P, Syrris V, Zanchetta L (2013). *A Global Human Settlement Layer From Optical HR/VHR RS Data*. doi.org/10.1109/ISTARS.2013.2271445.



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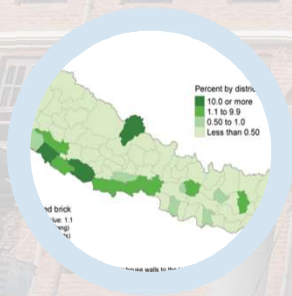


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FROM THE AMERICAN PEOPLE

FORCE PROJECT



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



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FROM THE AMERICAN PEOPLE



NSET
Disaster Resilient Communities in Nepal



Ministerio de Medio Ambiente y Recursos Naturales

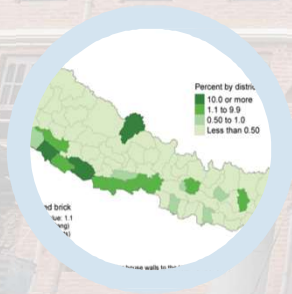


GLOBAL
QUAKE
MODEL
.ORG



GLOBAL EARTHQUAKE MODEL

Forecasting and Communicating Earthquake Hazard and Risk



Knowledge

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

Main Goal

Time-dependent risk models

On the exposure side:

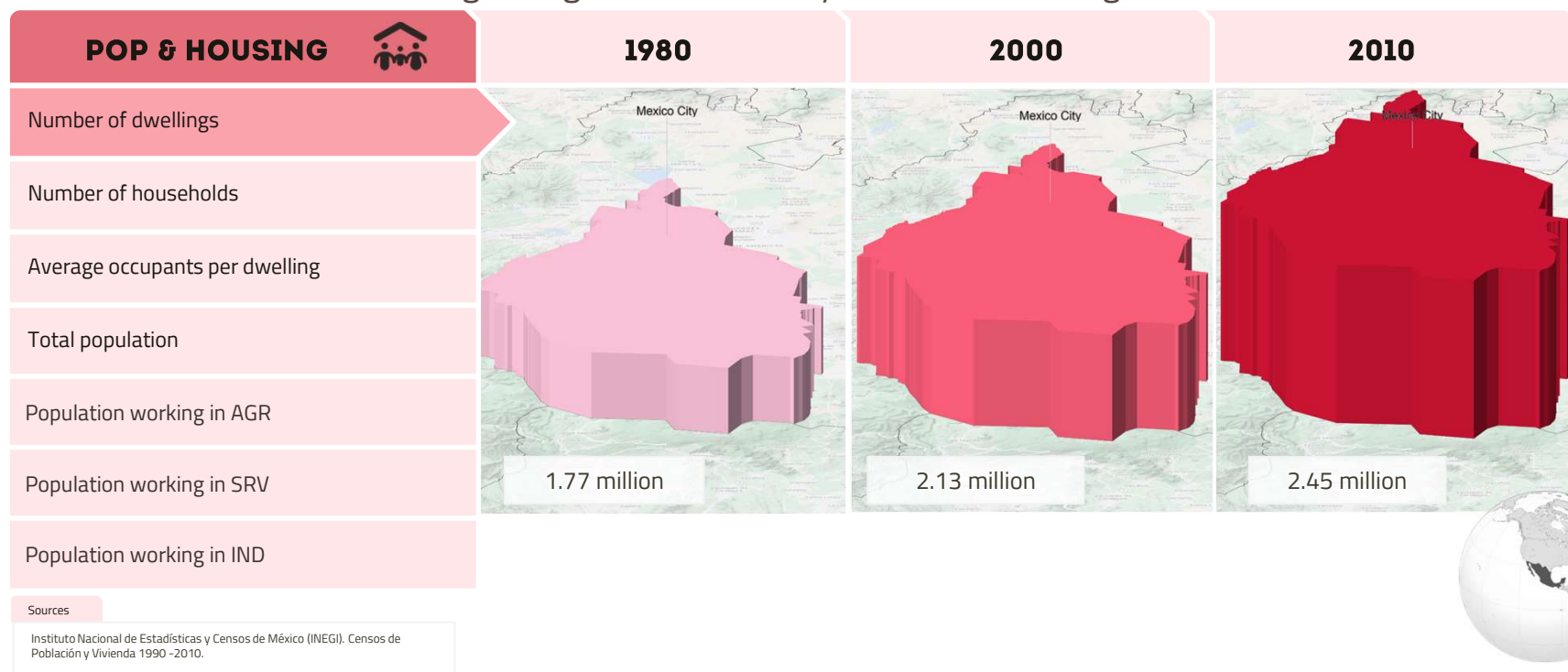
- ✓ Collect additional data for the drivers of urban growth around the world
- ✓ Explore better ways to account for these drivers in exposure forecasting

Scenarios of future exposure into national and global exposure models of the GRM

URBAN GROWTH AT SUBNATIONAL LEVEL

9

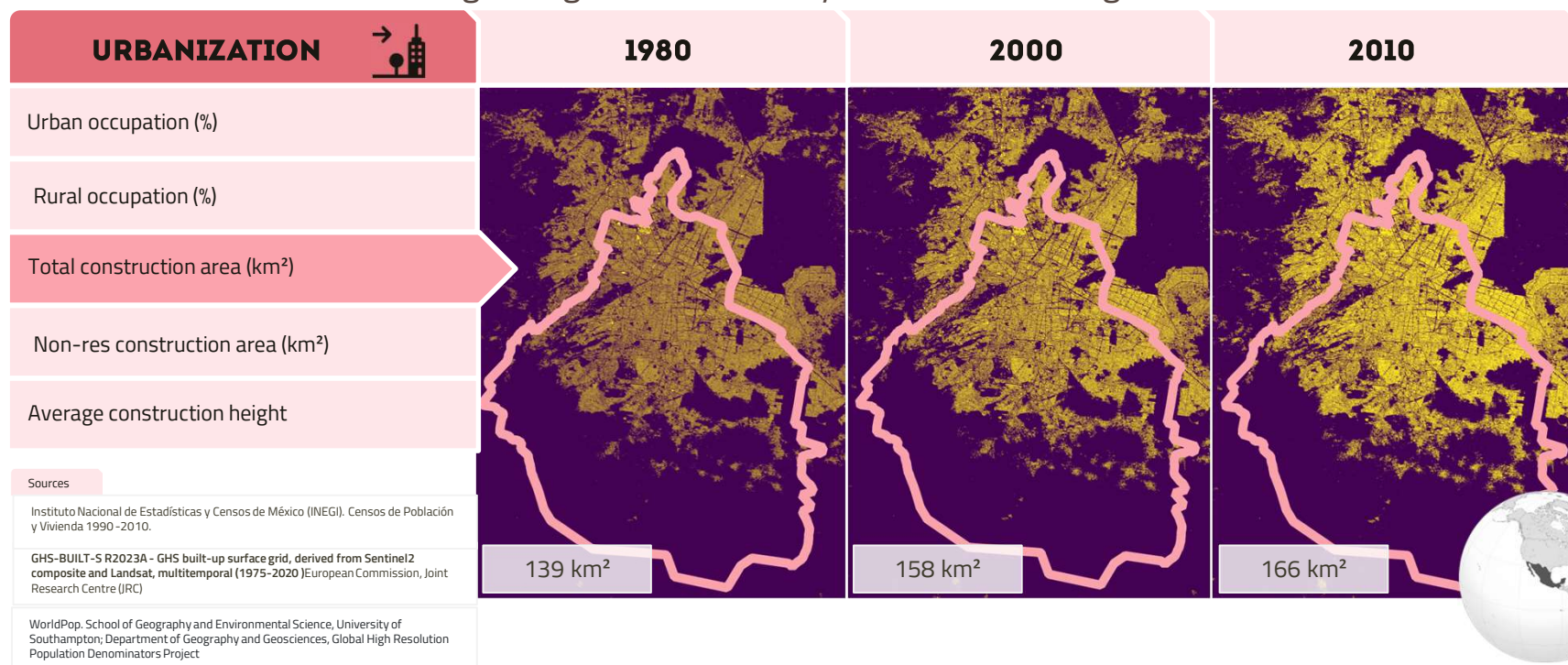
Observing changes in Mexico City administrative region across datasets and time



URBAN GROWTH AT SUBNATIONAL LEVEL

10

Observing changes in Mexico City administrative region across datasets and time



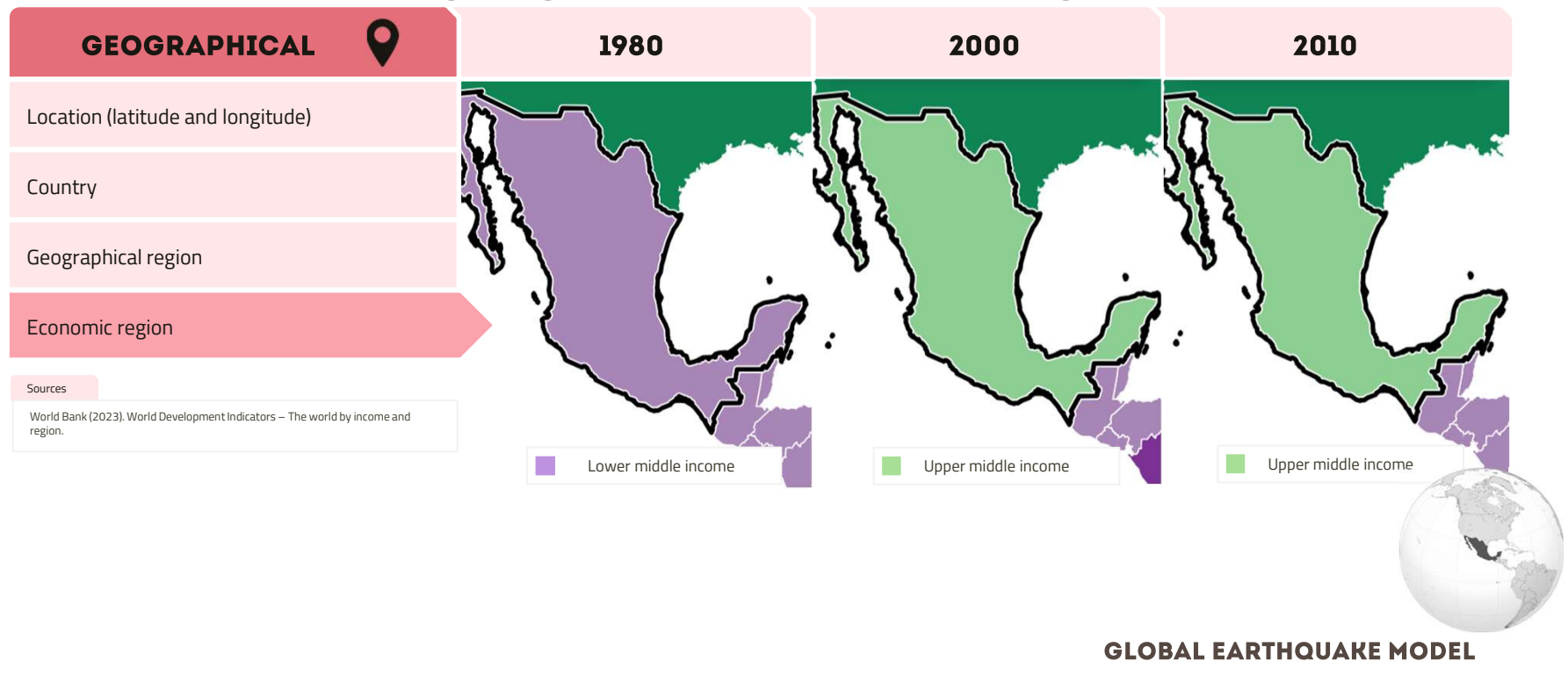
GLOBAL EARTHQUAKE MODEL



URBAN GROWTH AT SUBNATIONAL LEVEL

11

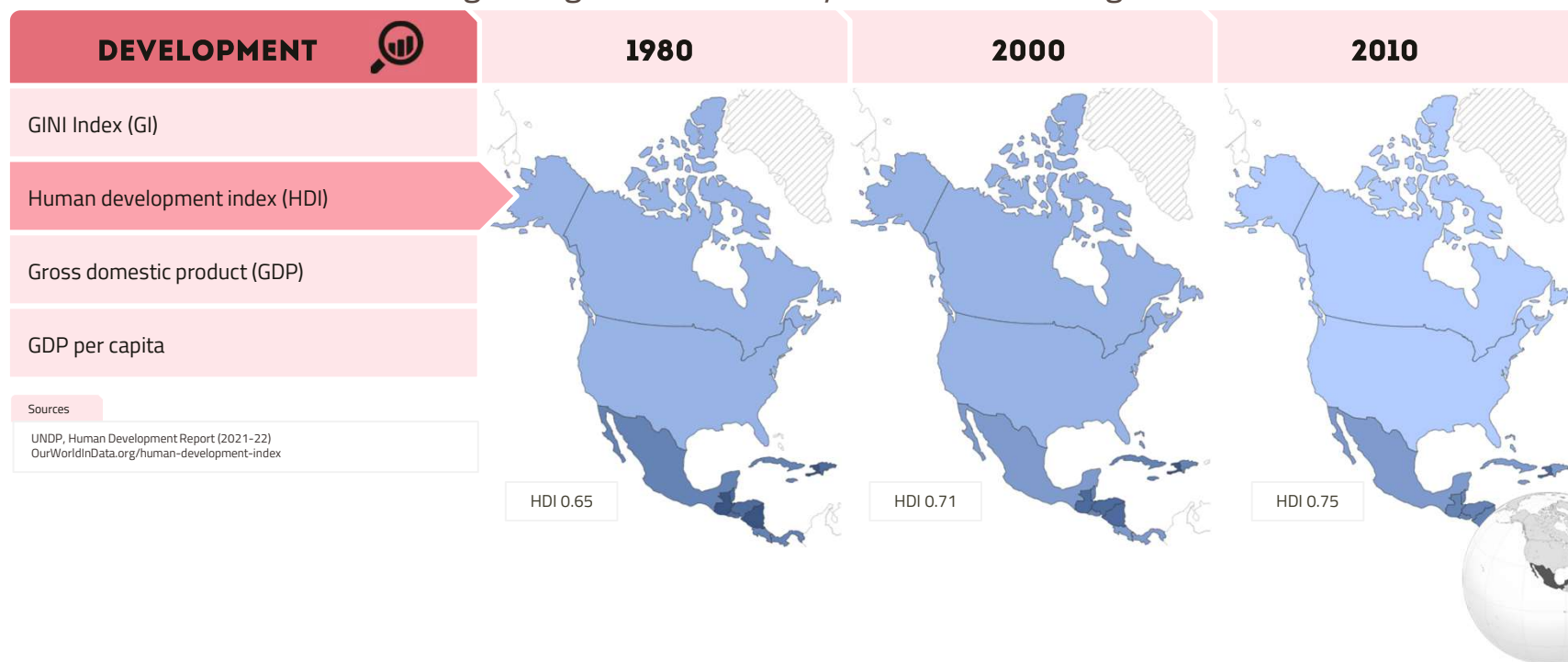
Observing changes in Mexico City administrative region across datasets and time



URBAN GROWTH AT SUBNATIONAL LEVEL

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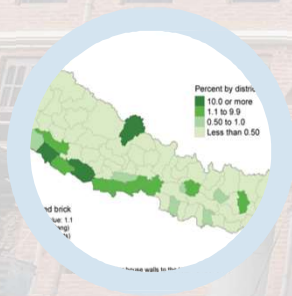
Observing changes in Mexico City administrative region across datasets and time



GLOBAL EARTHQUAKE MODEL



Forecasting and Communicating Earthquake Hazard and Risk



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

Main Goal

Time-dependent risk models

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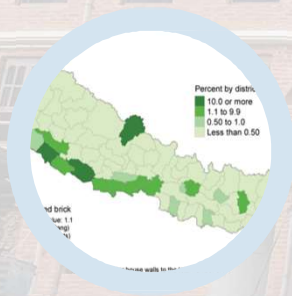
- ✓ Collect additional data for the drivers of urban growth around the world
- ✓ Explore better ways to account for these drivers in exposure forecasting

Progress so far:

- ✓ 36 countries
- ✓ 4 continents
- ✓ 135 urban clusters
- ✓ +2,000 regions
- ✓ 40 years of data
- ✓ 26 urban drivers

Scenarios of future exposure into national and global exposure models of the GRM

Forecasting and Communicating Earthquake Hazard and Risk



Knowledge

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

Main Goal

Time-dependent risk models

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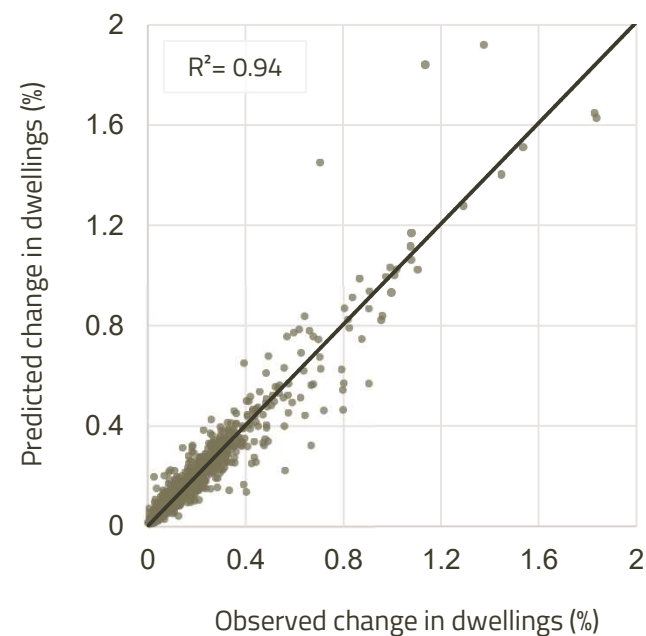
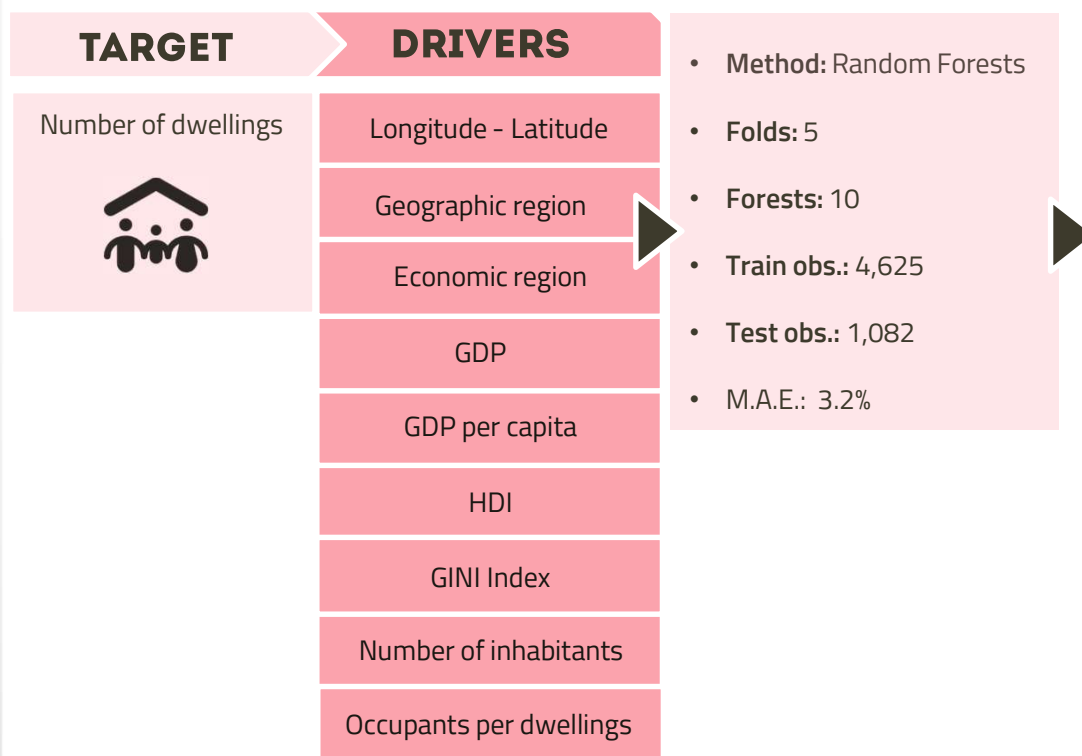
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Scenarios of future exposure into national and global exposure models of the GRM

HOW TO USE THIS FOR EXPOSURE FORECASTING?

15



GLOBAL EARTHQUAKE MODEL



HOW TO USE THIS FOR EXPOSURE FORECASTING?

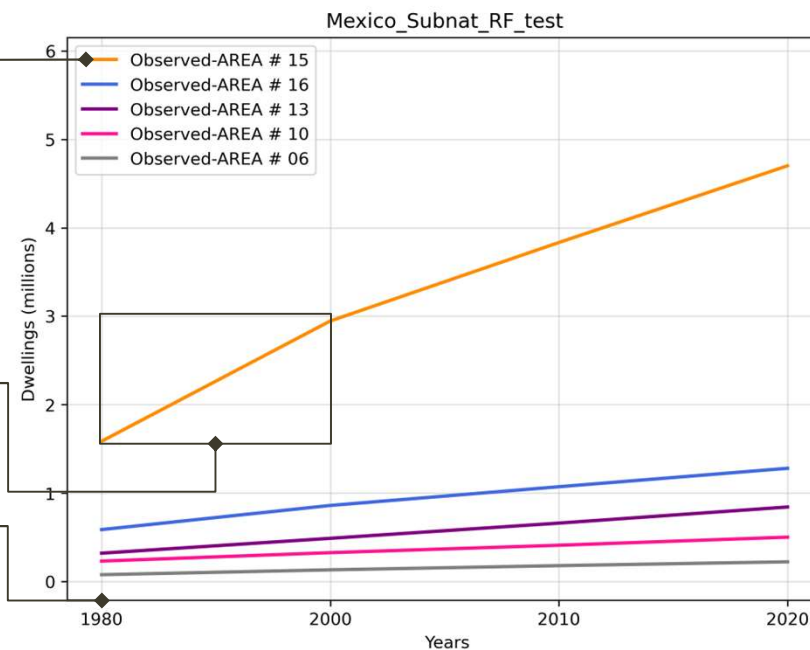
Known observations of
the exploratory variable



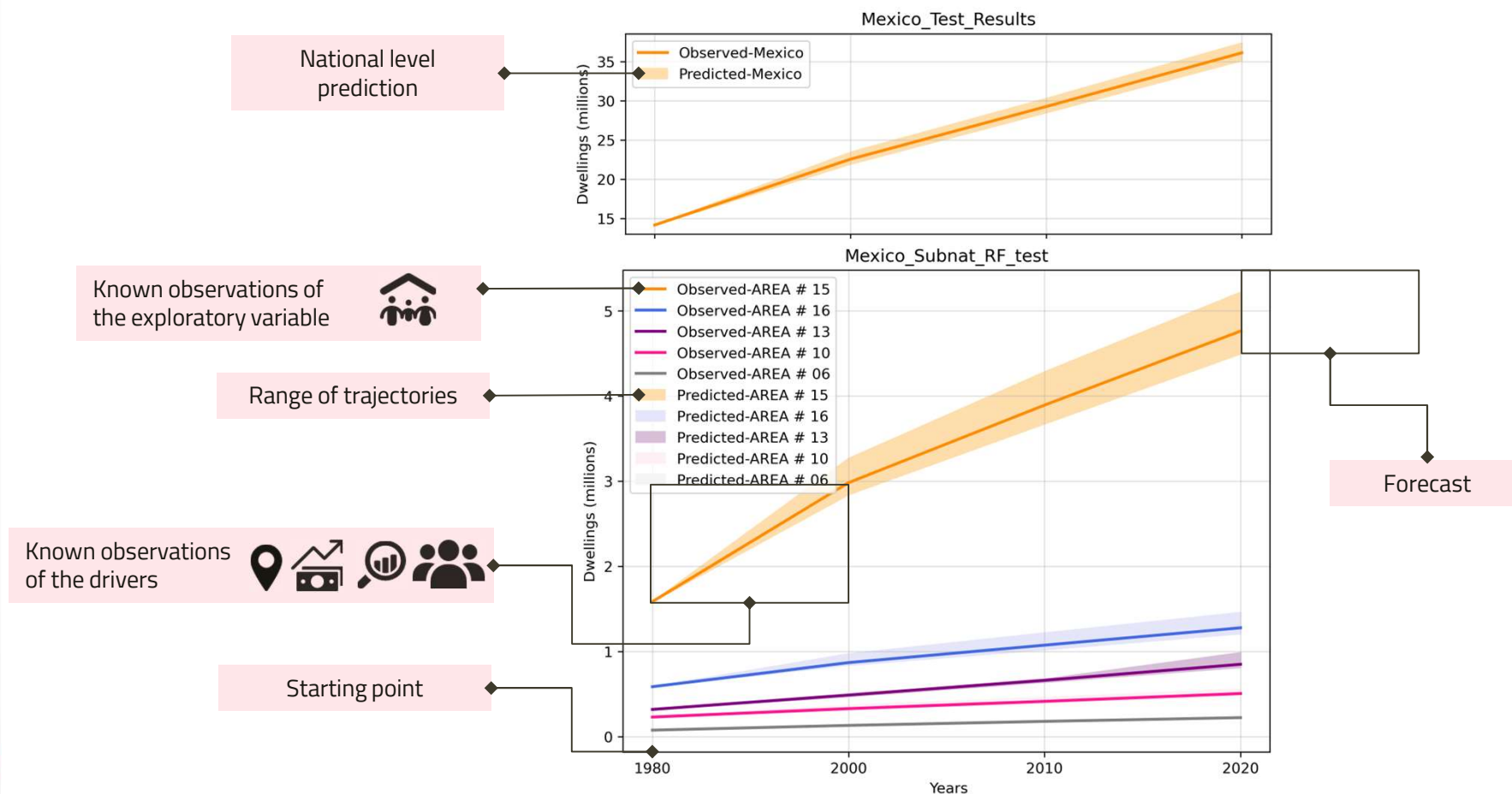
Known observations
of the drivers



Starting point



HOW TO USE THIS FOR EXPOSURE FORECASTING?



A FORECAST REQUIRES A NARRATIVE FOR THE FUTURE

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:



DEMOGRAPHIC



ECONOMIC

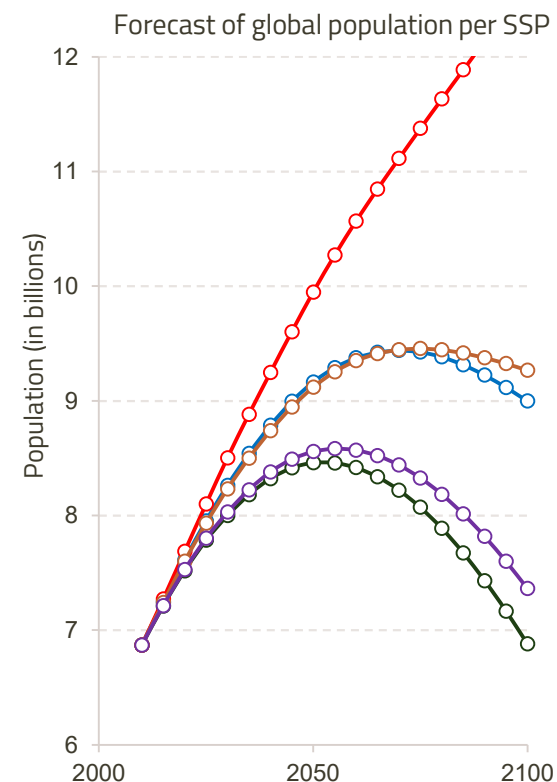
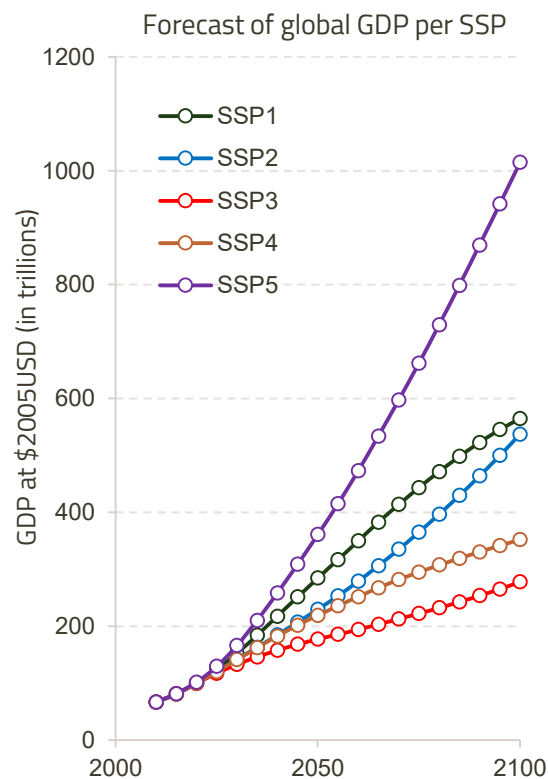


URBAN

Sources

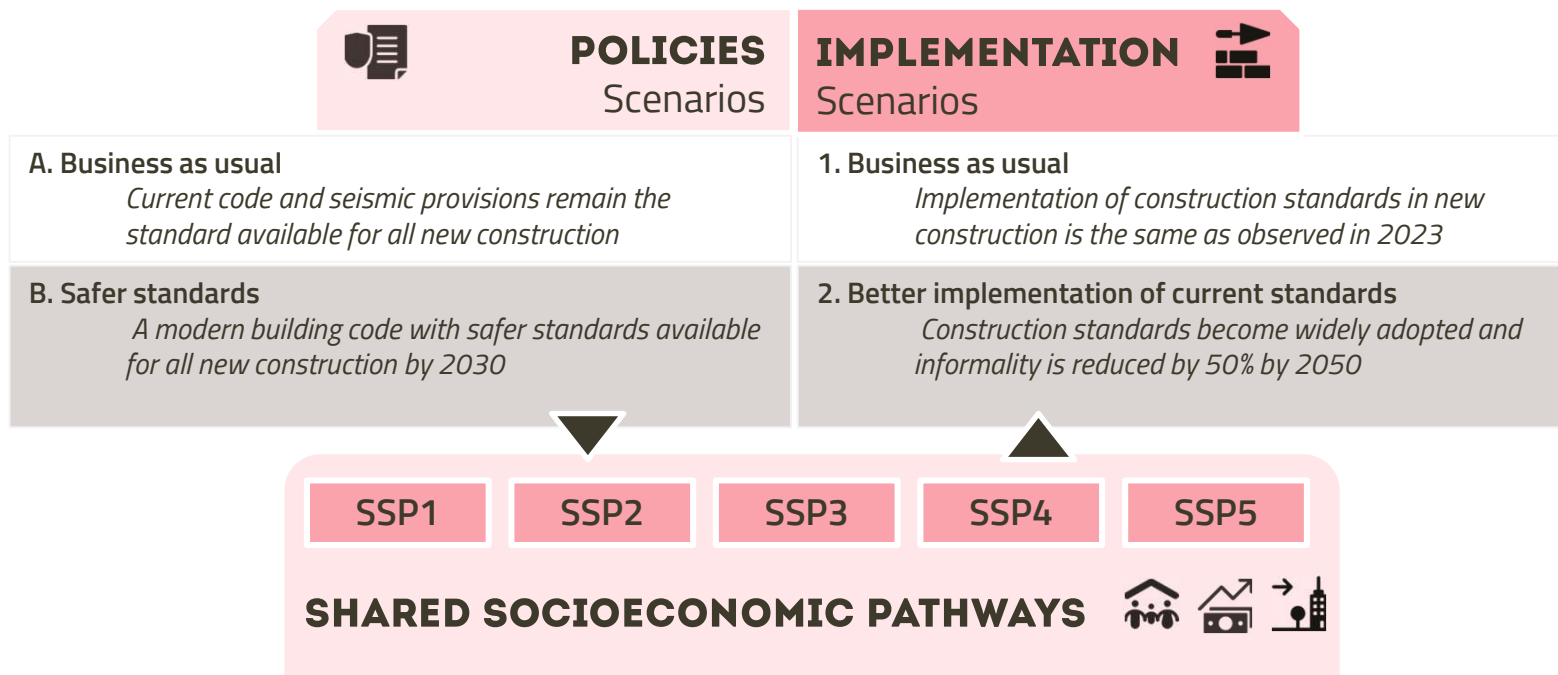
SSP Public Database (Version 2.0) <https://tntcat.iiasa.ac.at/SspDb>

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:10.1016/j.gloenvcha.2016.05.009



PROPOSING NARRATIVES FOR FUTURE VULNERABILITY

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WHERE ARE WE HEADED: SOUTH-EAST ASIA

20

All countries undergo the following two scenarios:

SSP2	(A.1)
Demographic growth: <i>mean fertility, life expectancy estimates</i> Development: <i>historical GDP, HDI trends</i>	Policyming: <i>business as usual</i> Implementation: <i>same as observed in 2023</i>
SSP2	(A.2)
Demographic growth: <i>mean fertility, life expectancy estimates</i> Development: <i>historical GDP, HDI trends</i>	Policyming: <i>business as usual</i> Implementation: <i>Standards widely adopted by 2050</i>



GLOBAL EARTHQUAKE MODEL



Scenario SSP2

2020

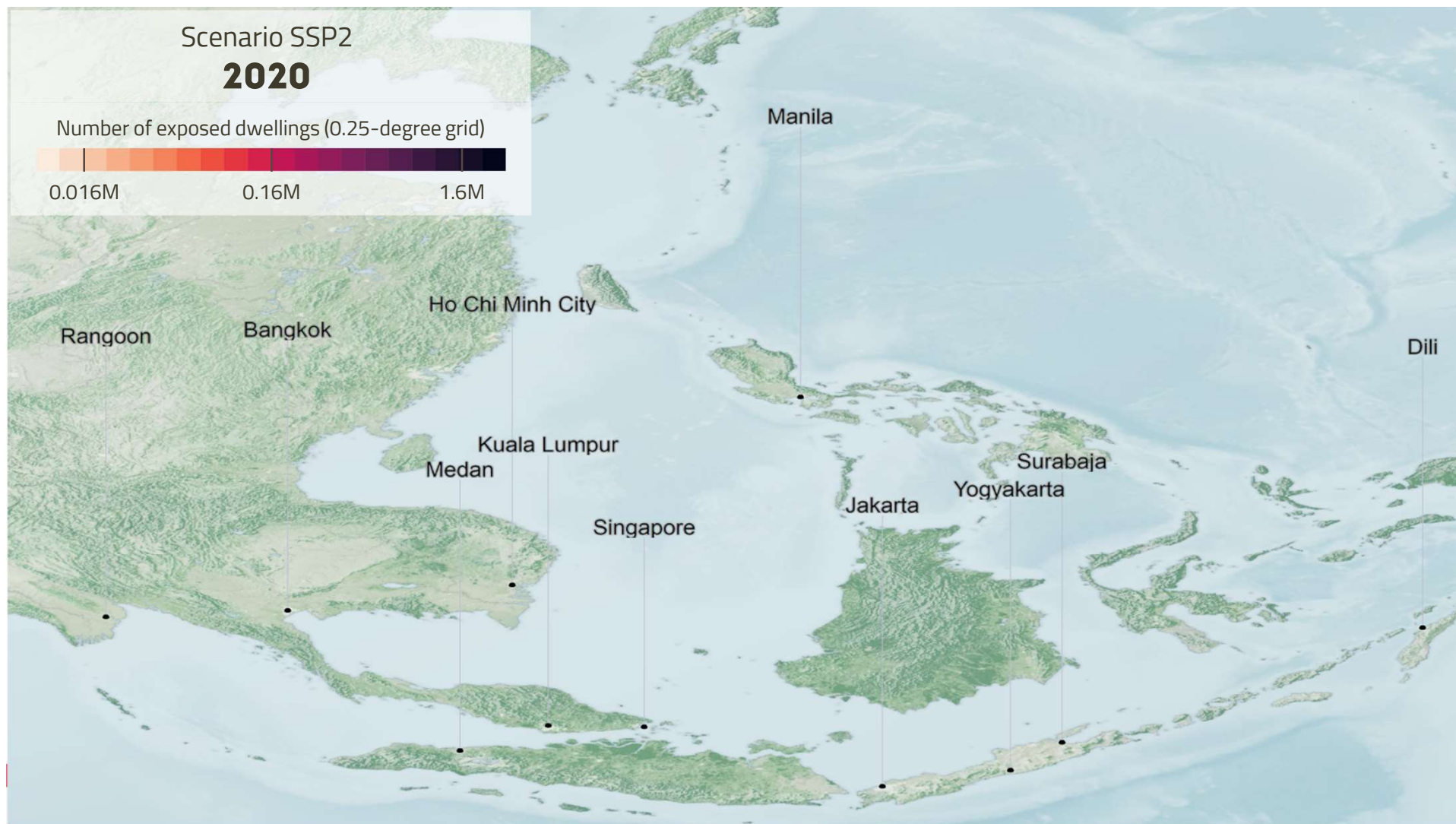
Number of exposed dwellings (0.25-degree grid)



0.016M

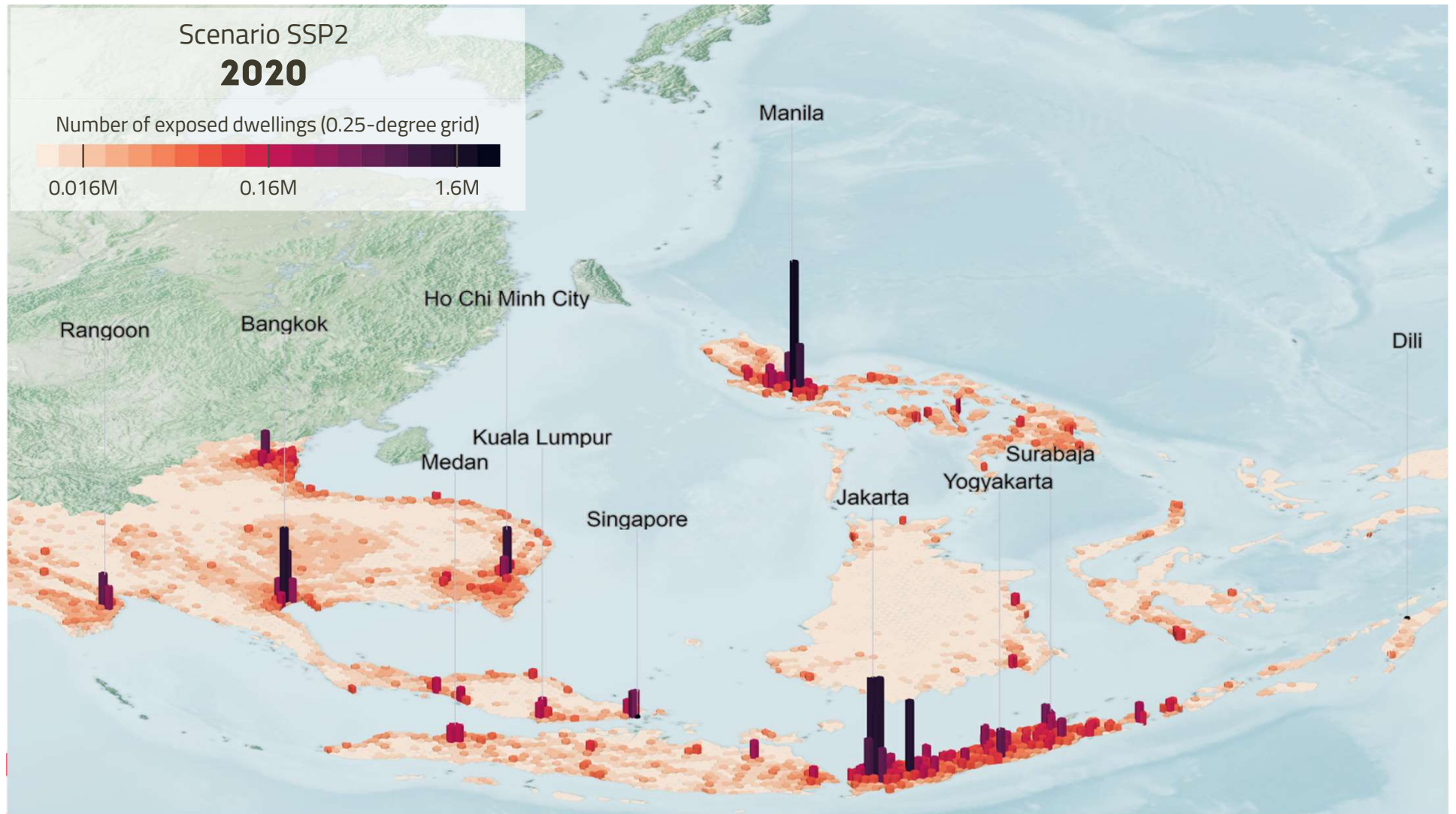
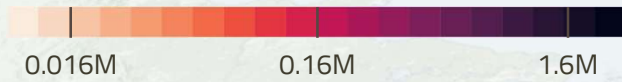
0.16M

1.6M



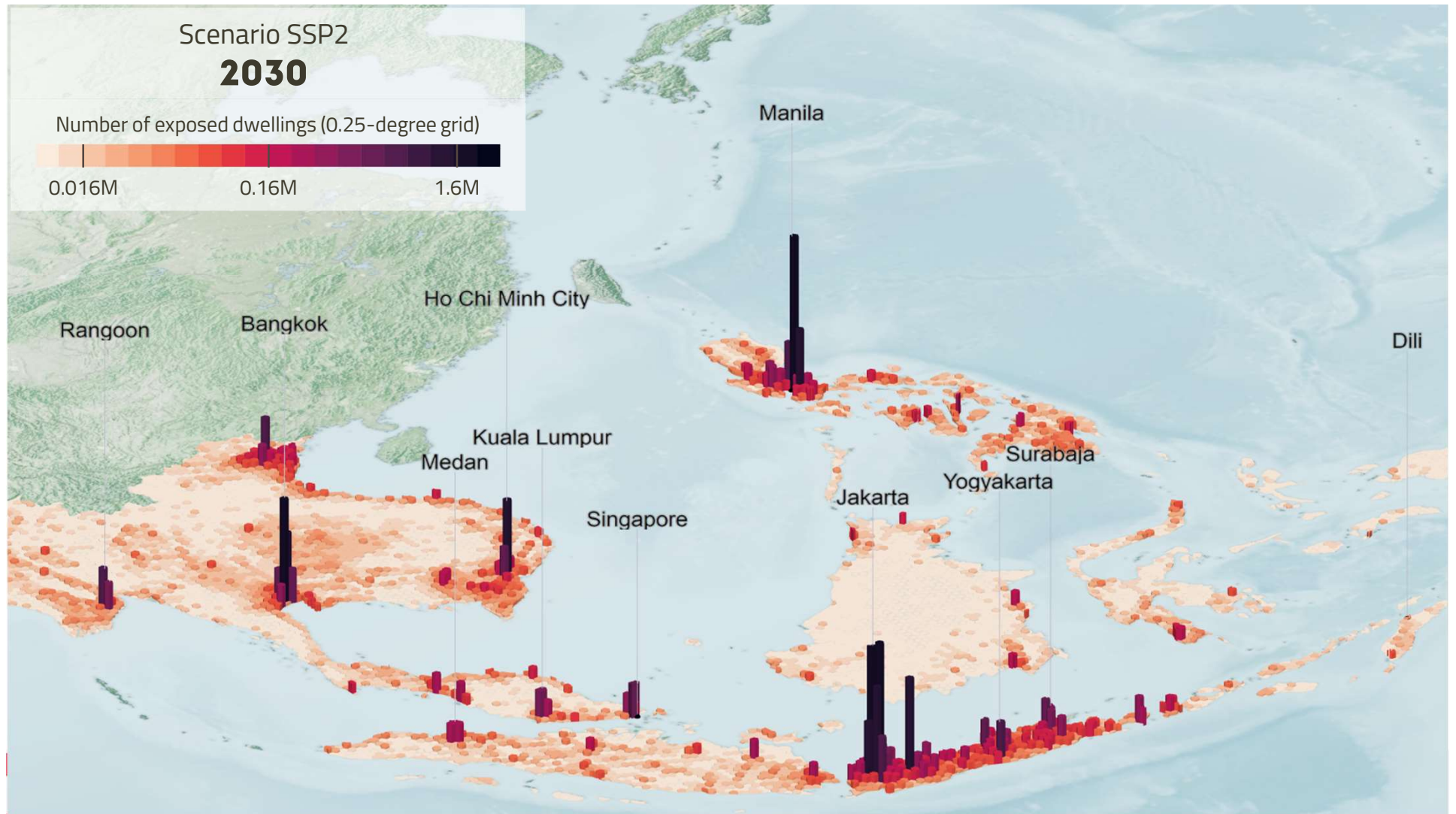
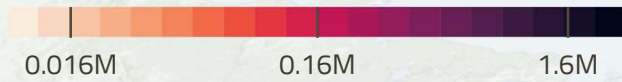
Scenario SSP2
2020

Number of exposed dwellings (0.25-degree grid)



Scenario SSP2
2030

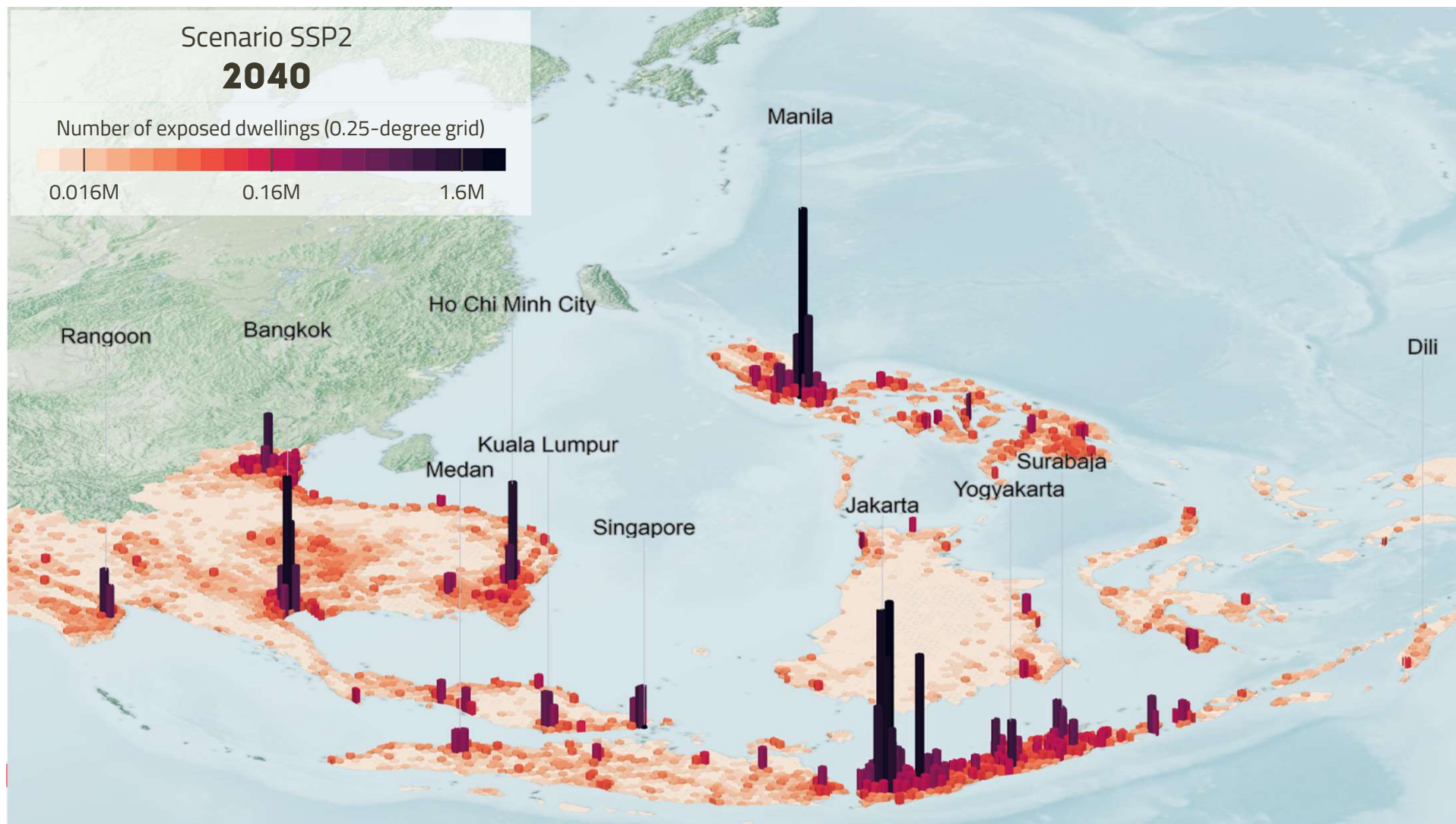
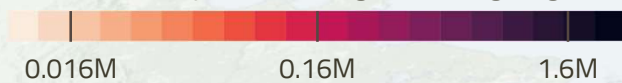
Number of exposed dwellings (0.25-degree grid)



Scenario SSP2

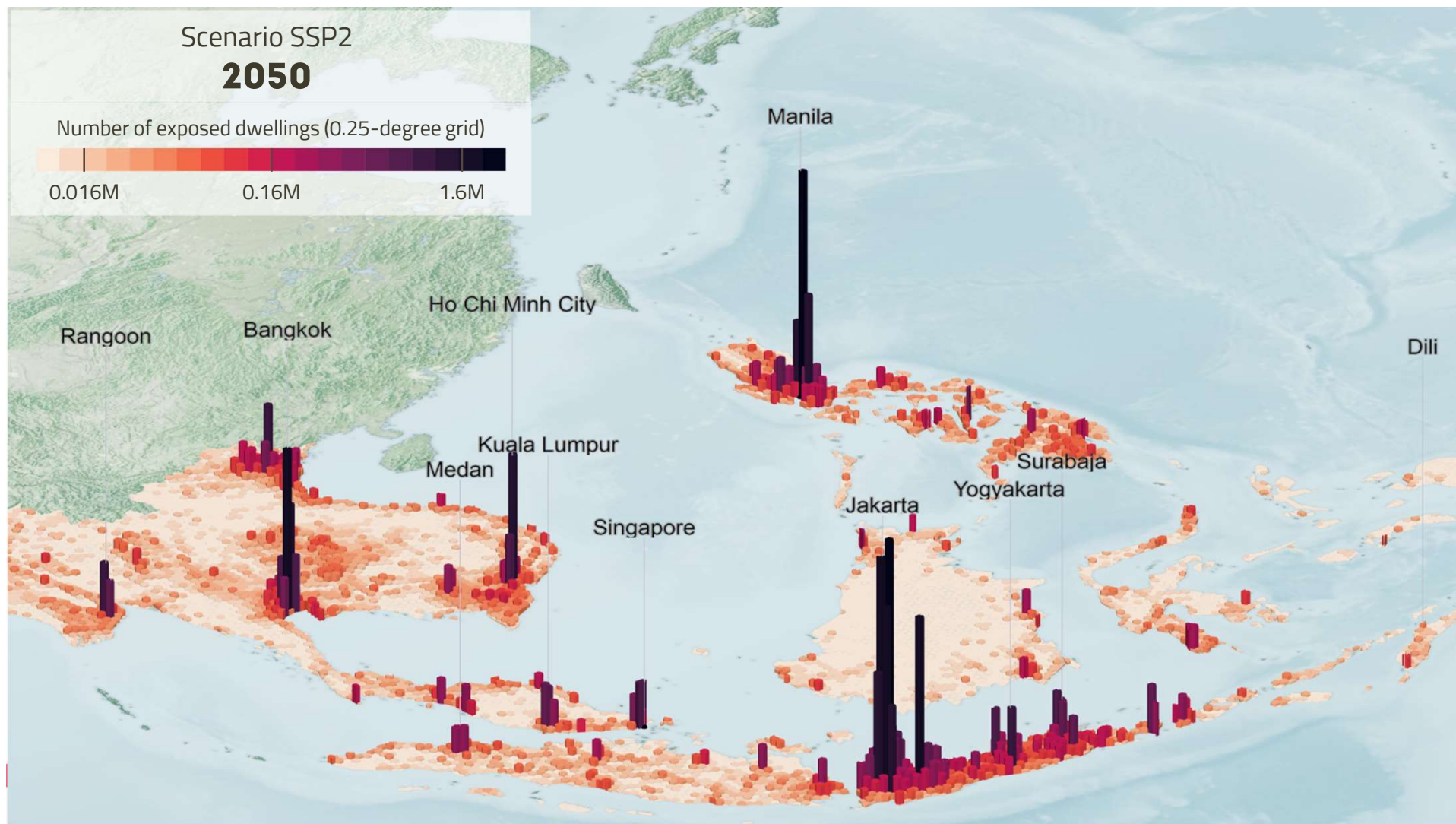
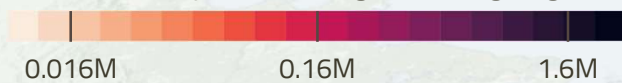
2040

Number of exposed dwellings (0.25-degree grid)



Scenario SSP2
2050

Number of exposed dwellings (0.25-degree grid)



Scenario SSP2
2020

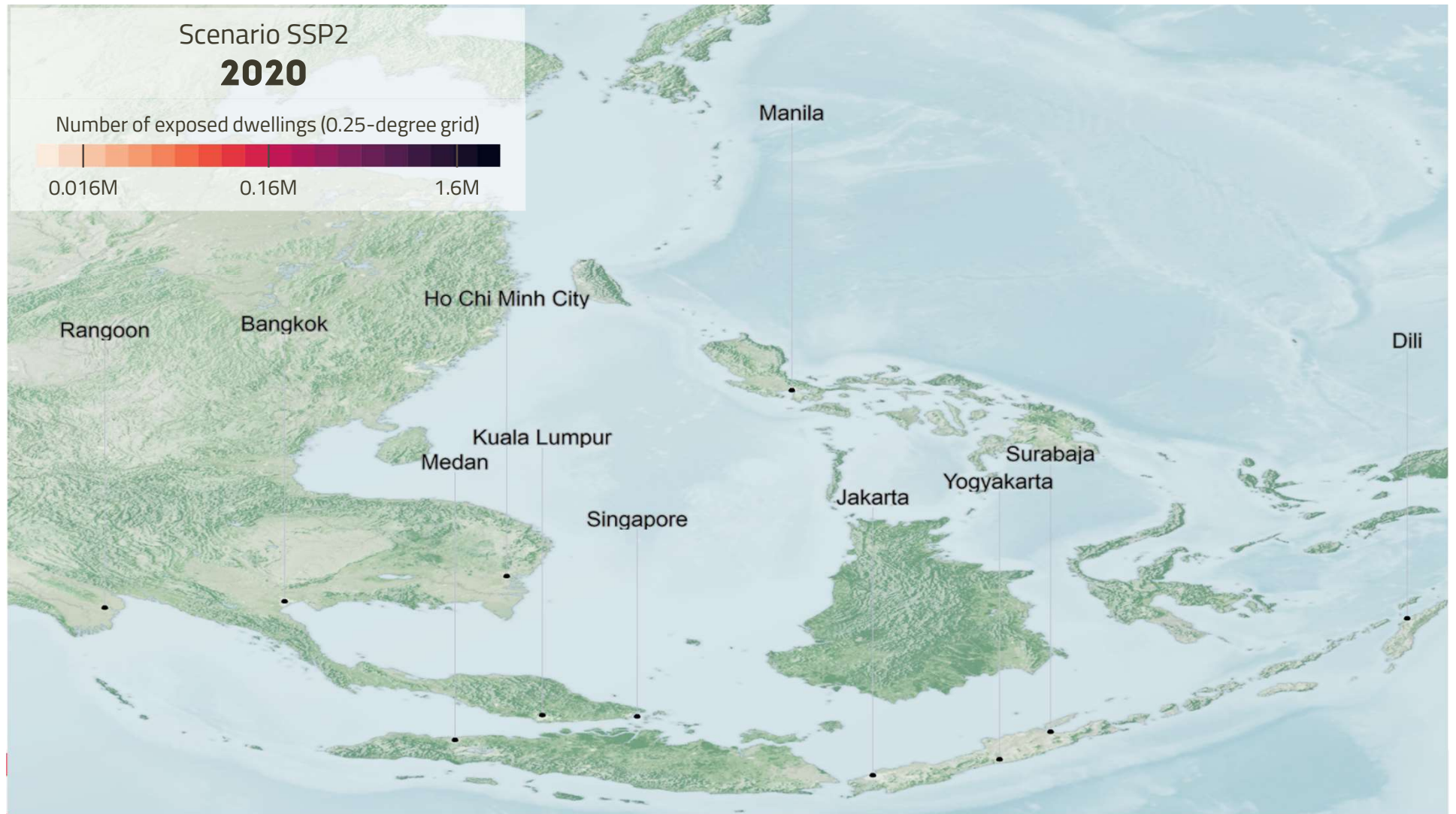
Number of exposed dwellings (0.25-degree grid)



0.016M

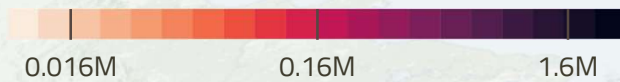
0.16M

1.6M

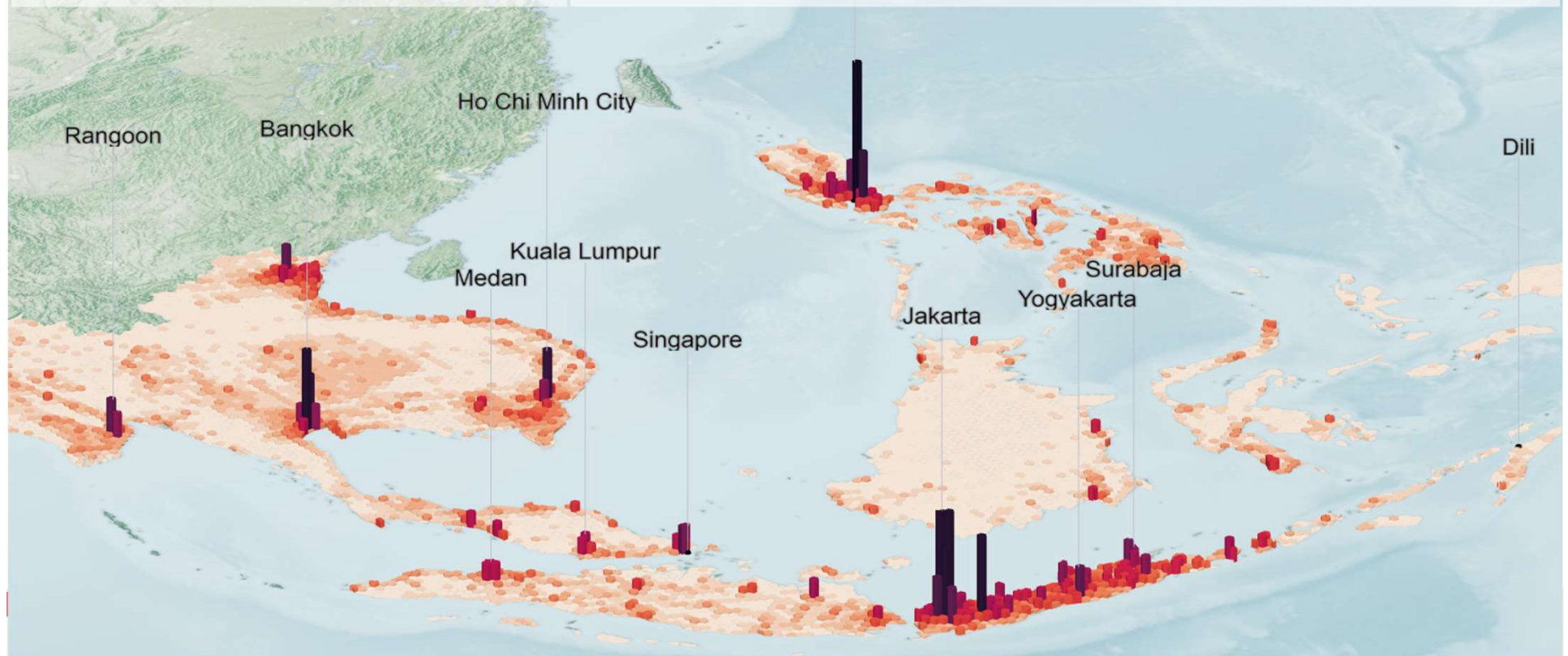
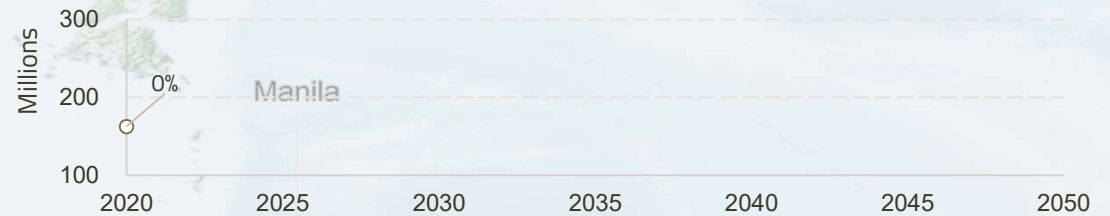


Scenario SSP2
2020

Number of exposed dwellings (0.25-degree grid)

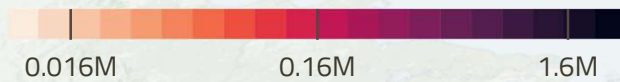


Increase in the number of exposed dwellings in Southeast Asia

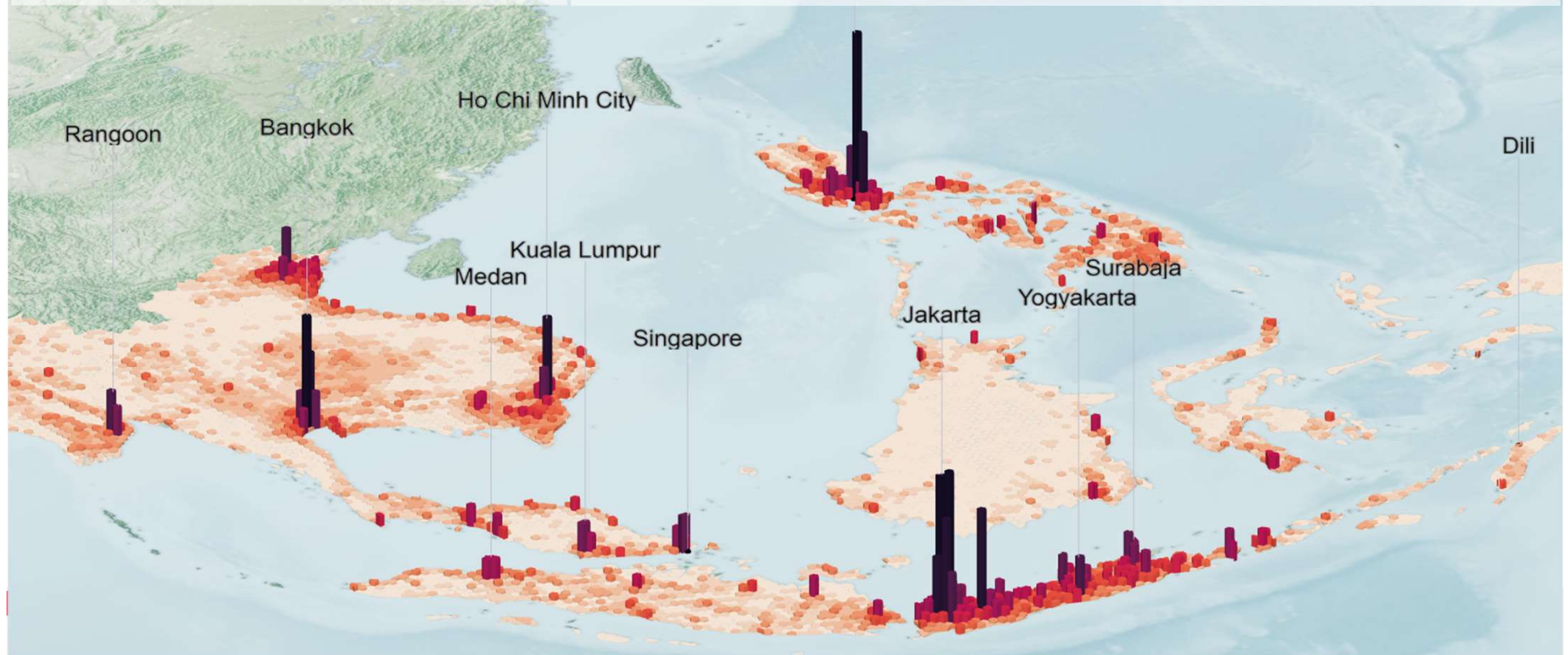
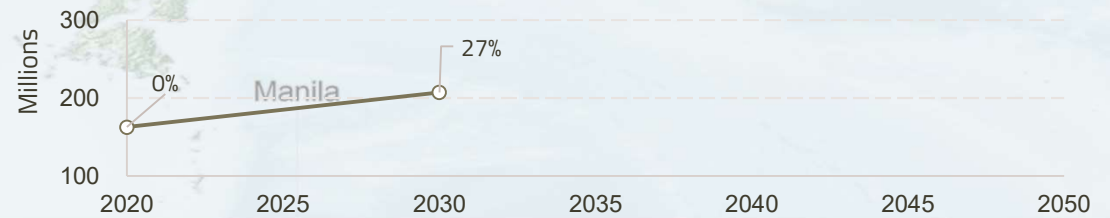


Scenario SSP2
2030

Number of exposed dwellings (0.25-degree grid)

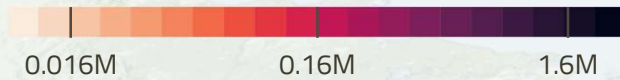


Increase in the number of exposed dwellings in Southeast Asia

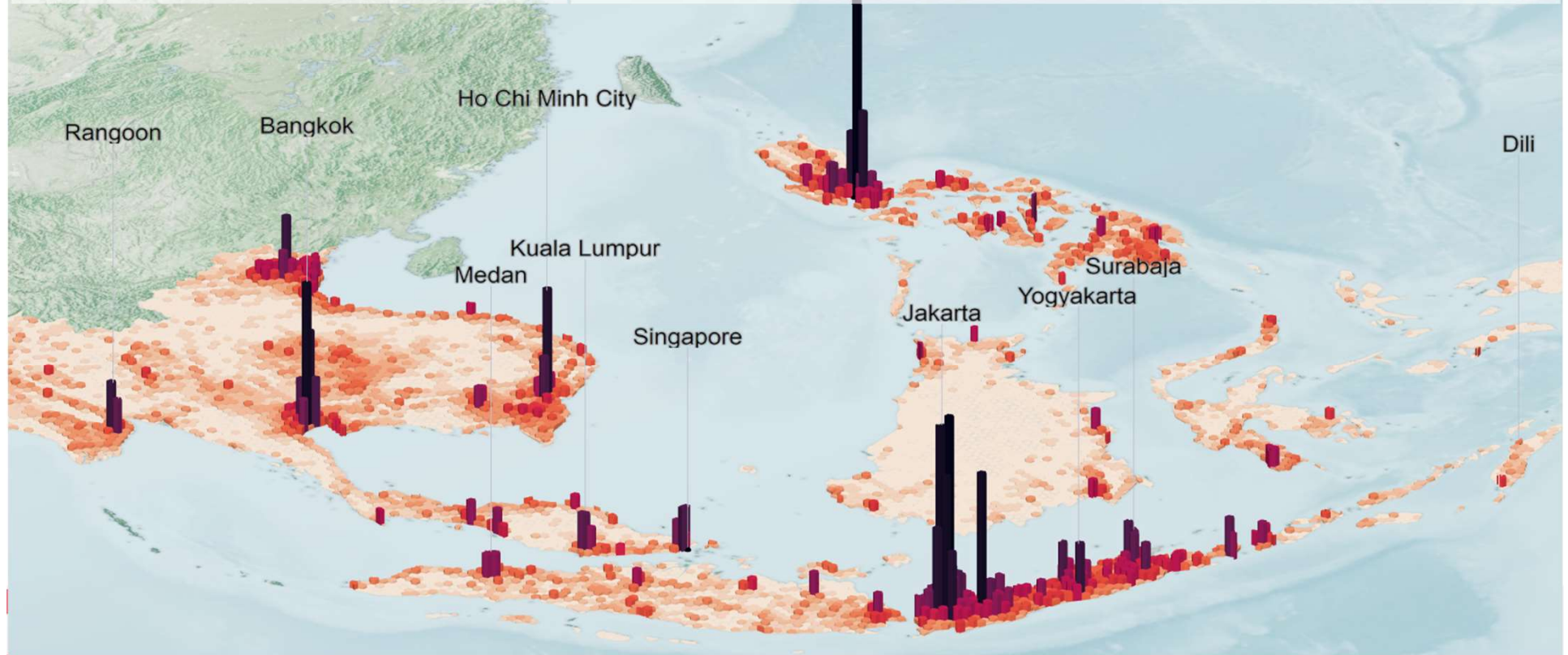
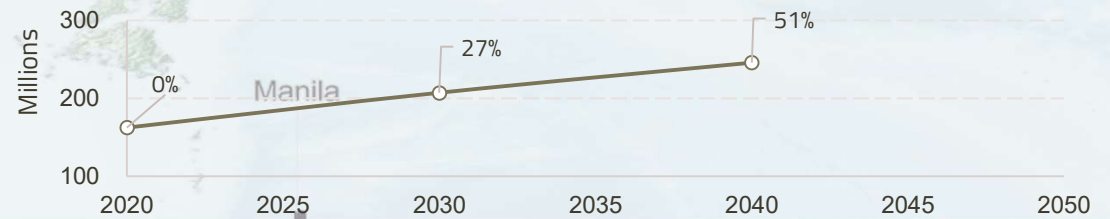


Scenario SSP2
2040

Number of exposed dwellings (0.25-degree grid)

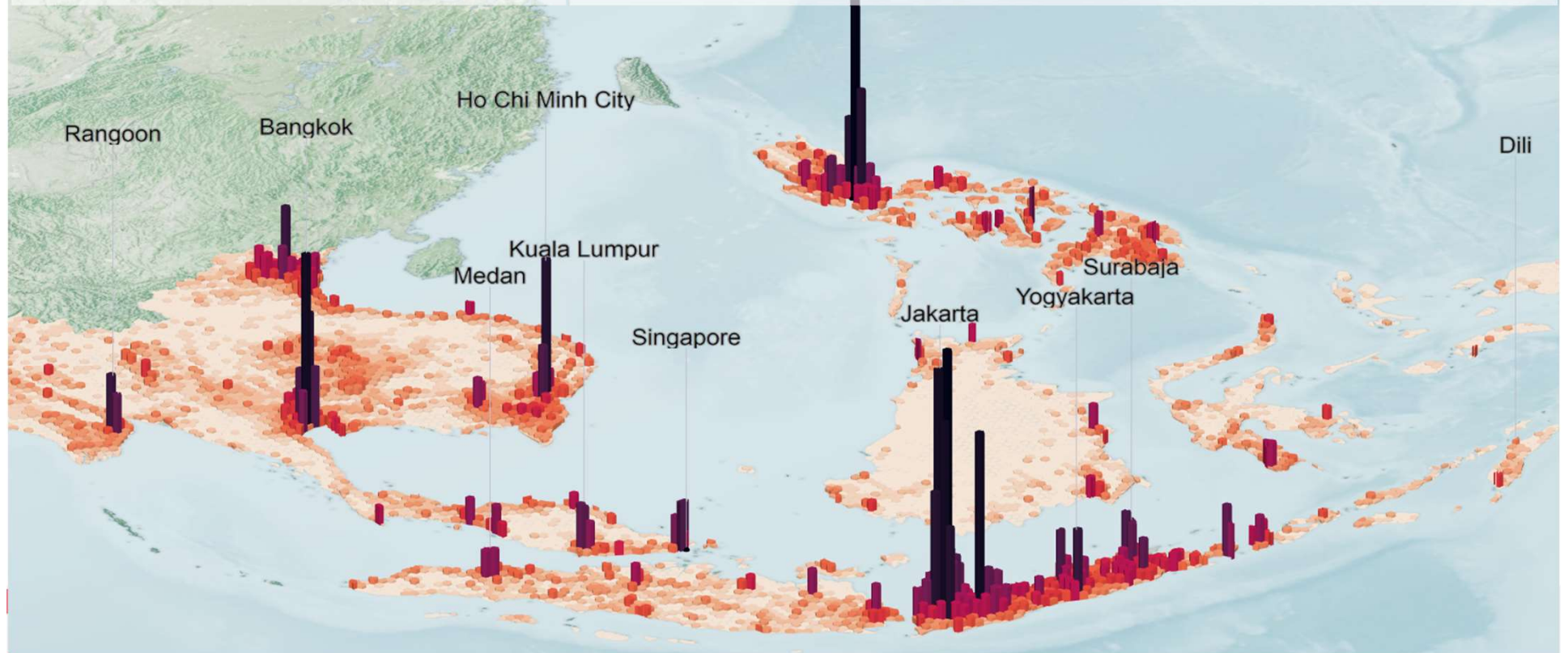
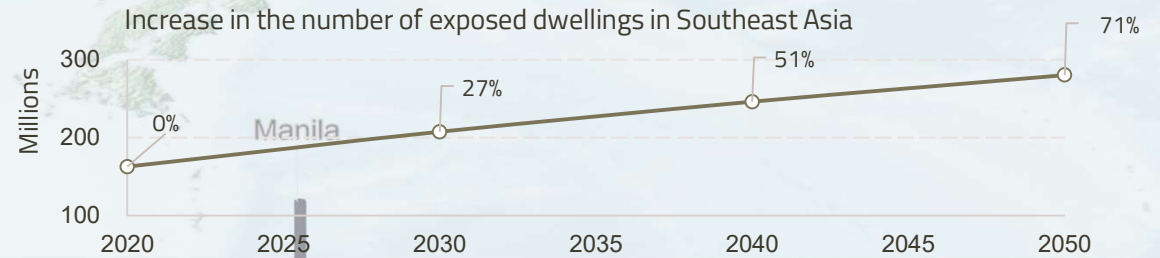
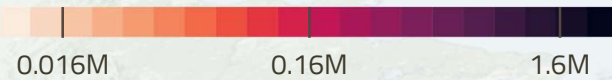


Increase in the number of exposed dwellings in Southeast Asia



Scenario SSP2
2050

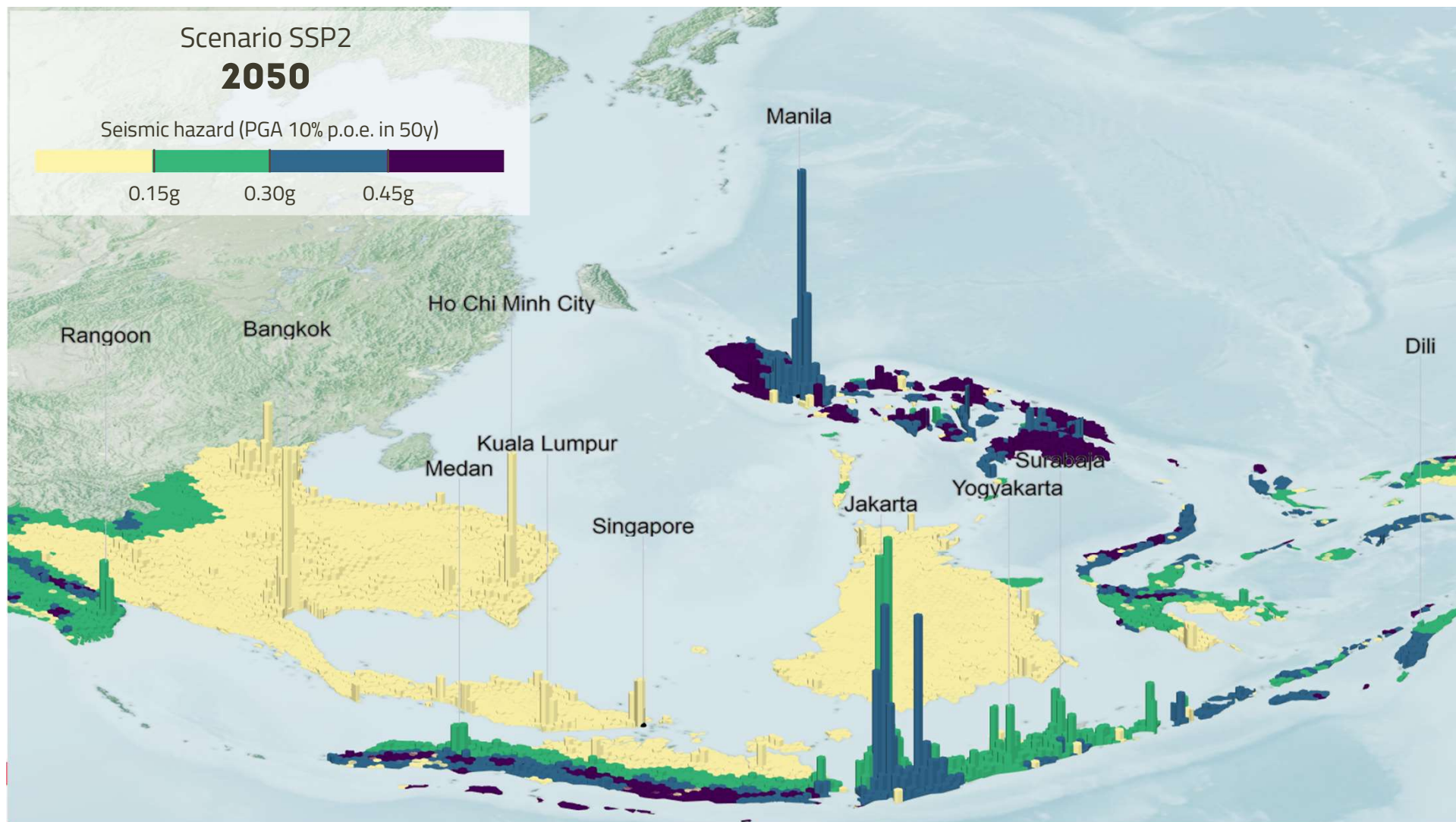
Number of exposed dwellings (0.25-degree grid)



Scenario SSP2

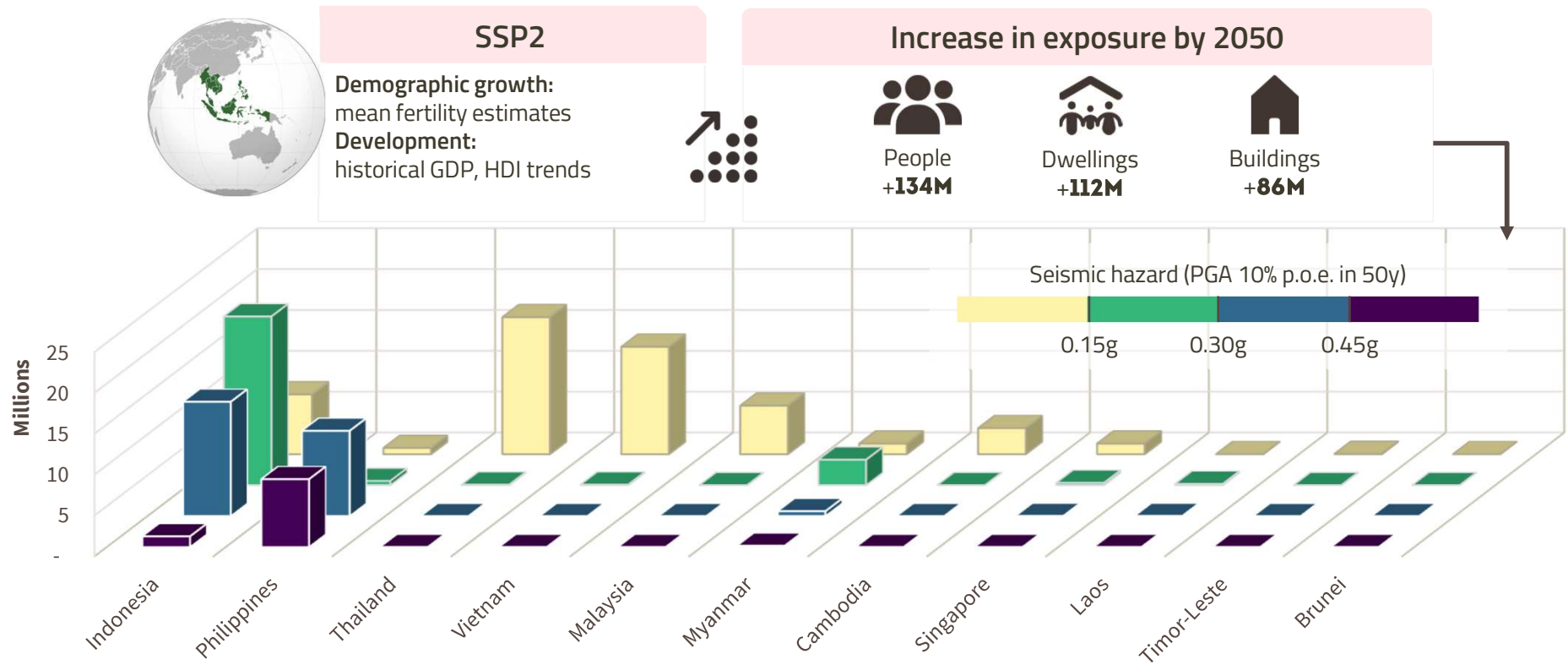
2050

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



WHERE ARE WE HEADED: SOUTH-EAST ASIA

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WHERE ARE WE HEADED: SOUTH-EAST ASIA



SSP2

Demographic growth:
mean fertility estimates
Development:
historical GDP, HDI trends



Total exposure by 2050



People
789M



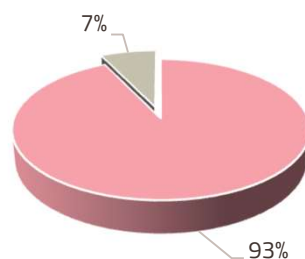
Dwellings
278M



Buildings
212M

SSP2 (A.1)

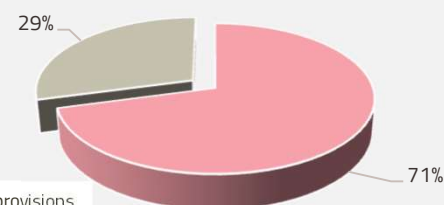
Policyming: *business as usual*
Implementation: *same as observed in 2023*



VS

SSP2 (A.2)

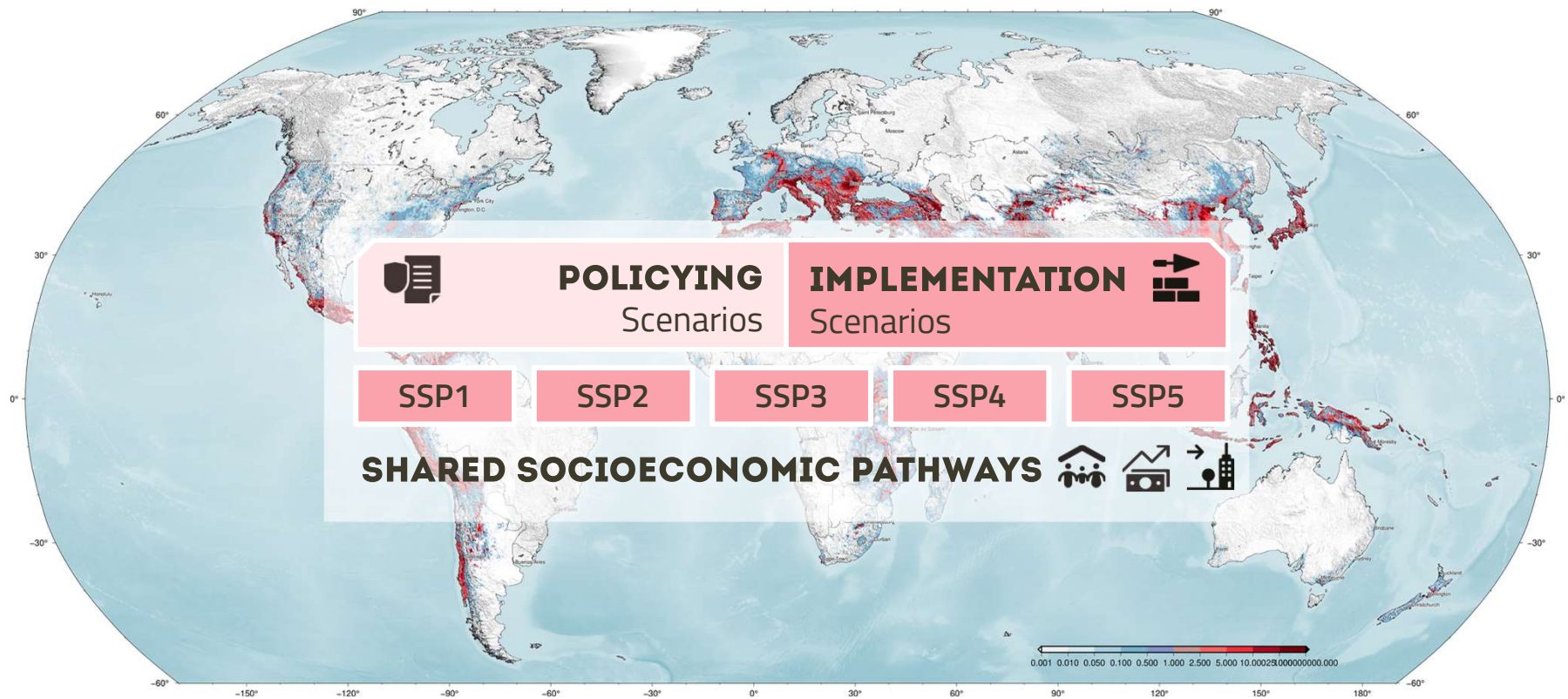
Policyming: *business as usual*
Implementation: *standards widely adopted by 2050*



Insufficient seismic provisions
Adequate seismic provisions

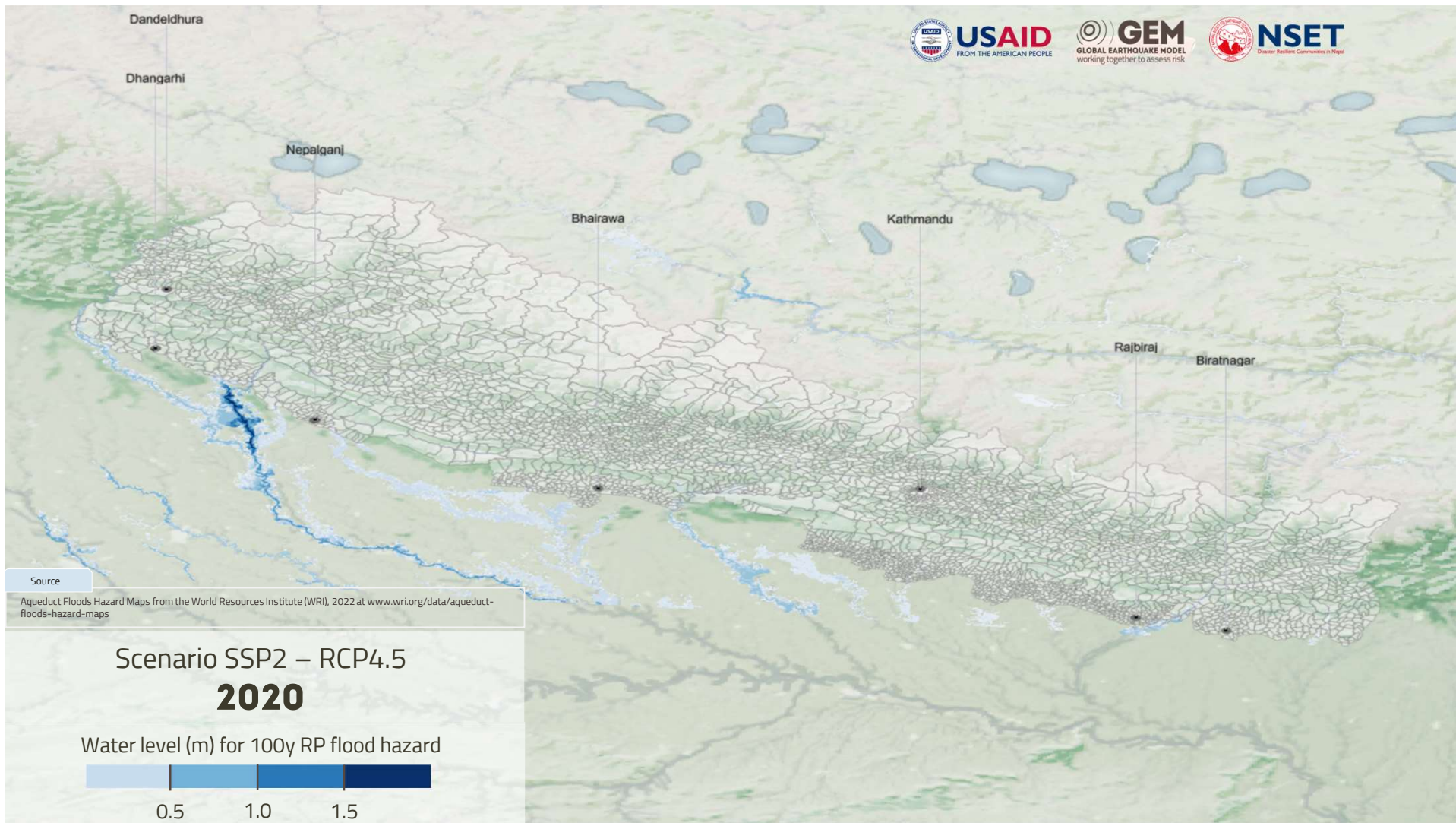
FUTURE WORK

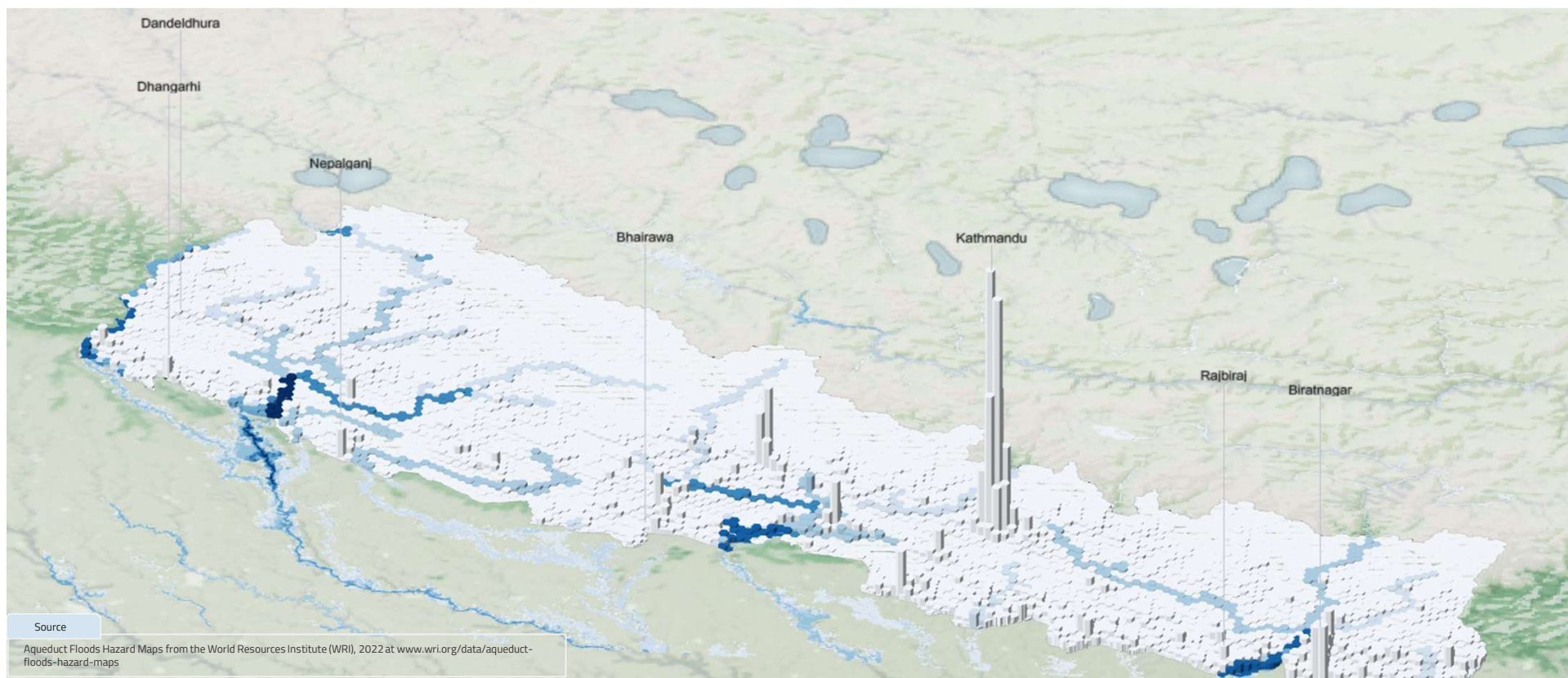
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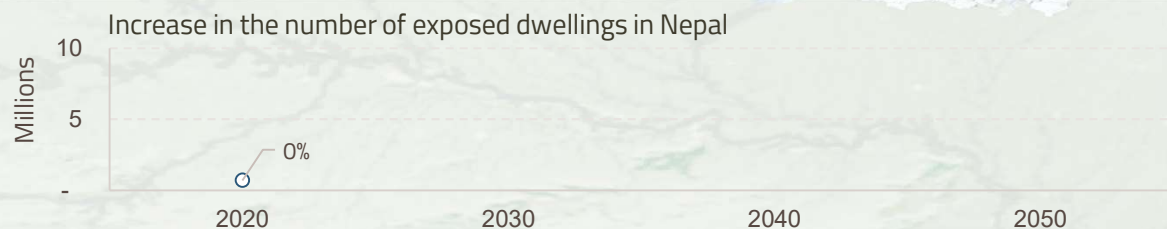
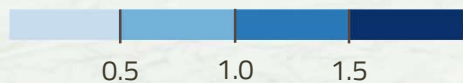


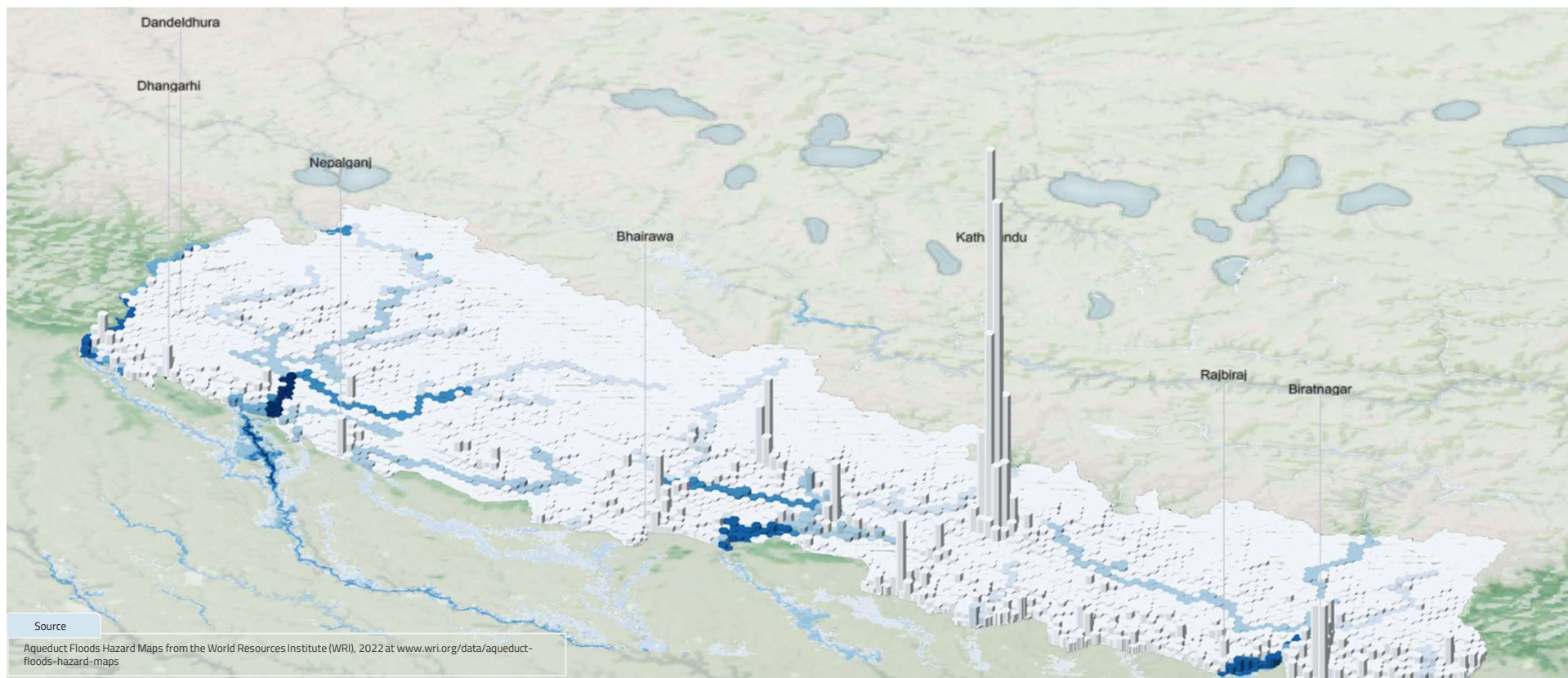
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Aqueduct Floods Hazard Maps from the World Resources Institute (WRI), 2022 at www.wri.org/data/aqueduct-floods-hazard-maps

Scenario SSP2 – RCP4.5 2020

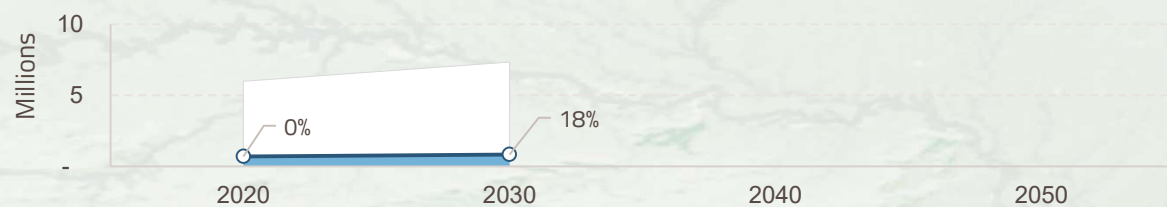
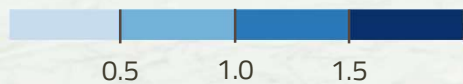
Water level (m) for 100y RP flood hazard

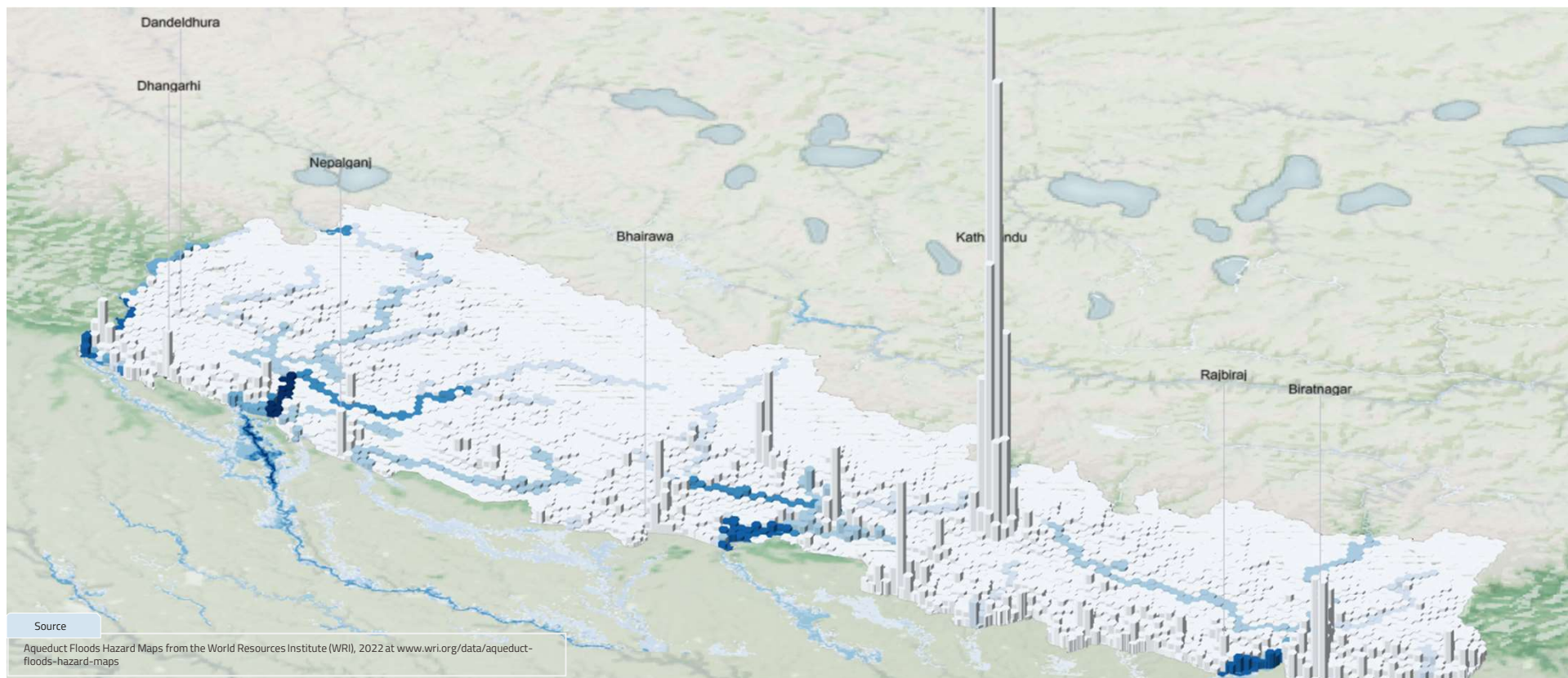




Scenario SSP2 – RCP4.5
2030

Water level (m) for 100y RP flood hazard



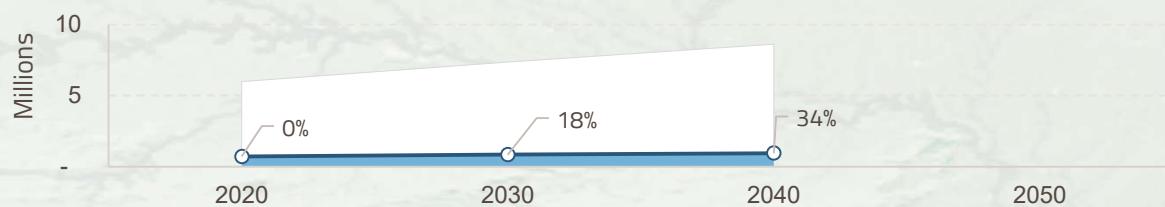


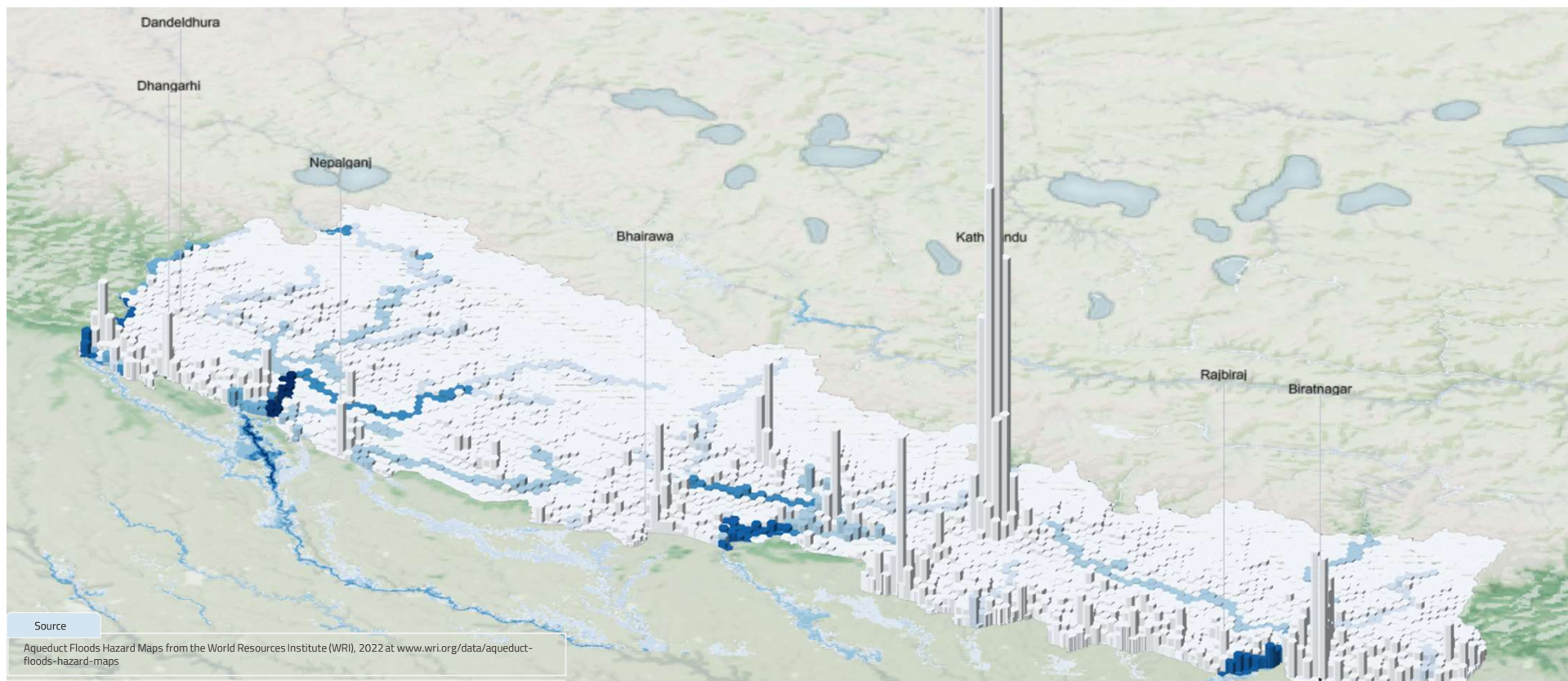
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Scenario SSP2 – RCP4.5 2040

Water level (m) for 100y RP flood hazard



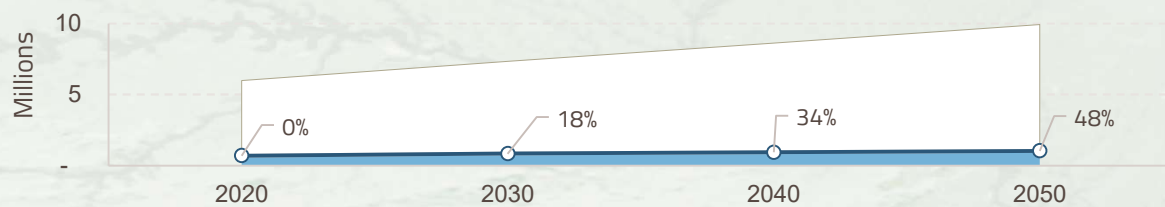


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Scenario SSP2 – RCP4.5 2050

Water level (m) for 100y RP flood hazard



THANKS FOR JOINING! GEM CONFERENCE

Are we making a difference?

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13th - 14th June 2023
Centro Congressi Bergamo
Bergamo, Italy

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