



Co-funded by
the European Union



Helmholtz Centre
for Geosciences

Every Building on Earth

The Global Dynamic Exposure Model/Platform

Danijel Schorlemmer

Laurens Oostwegel, Tara Evaz Zadeh, Lars Lingner,
Pablo de La Mora Lobaton, Chengzhi Rao, Doren Calliku

GFZ Potsdam

Vesuvius Area

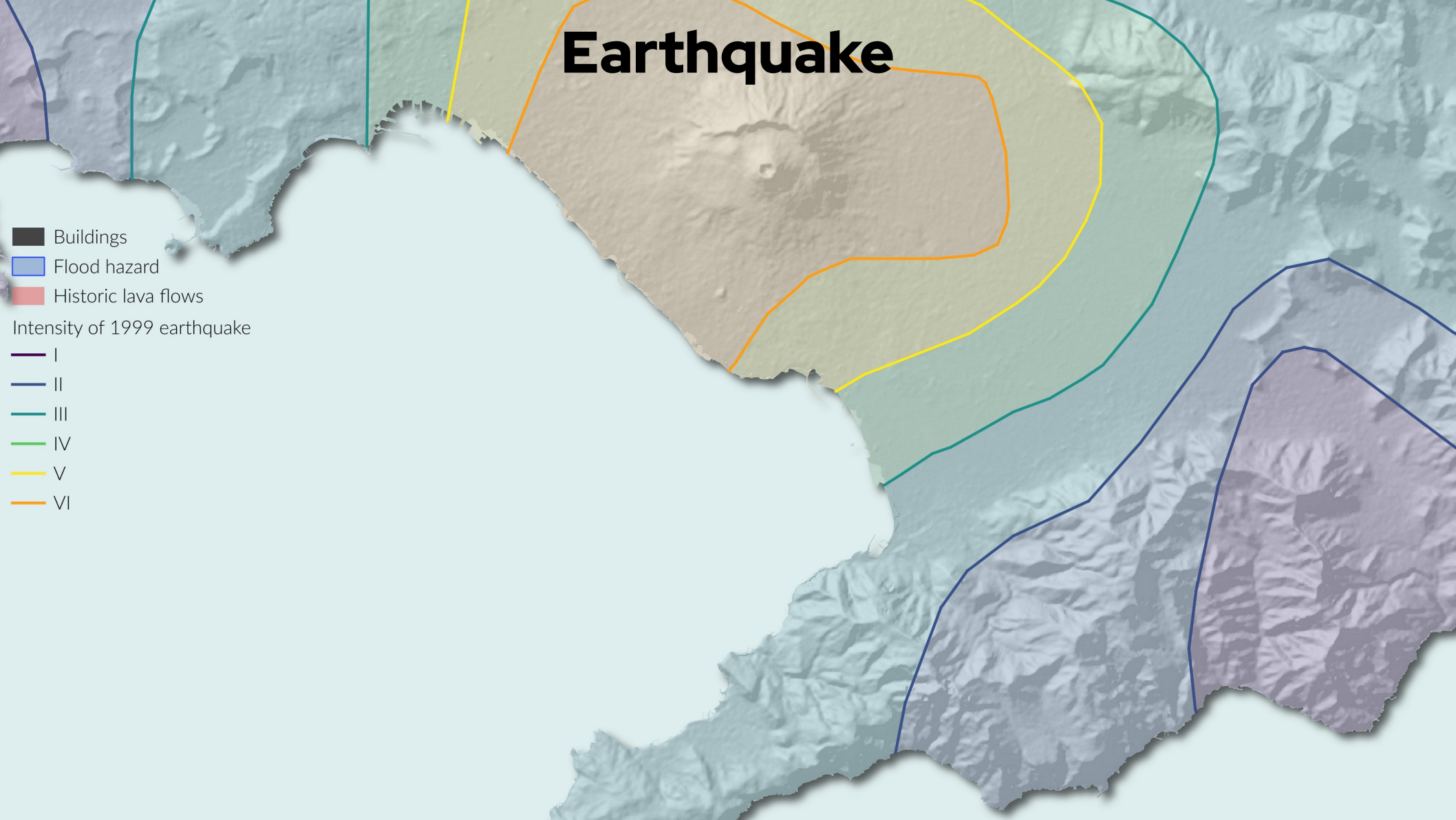


Earthquake

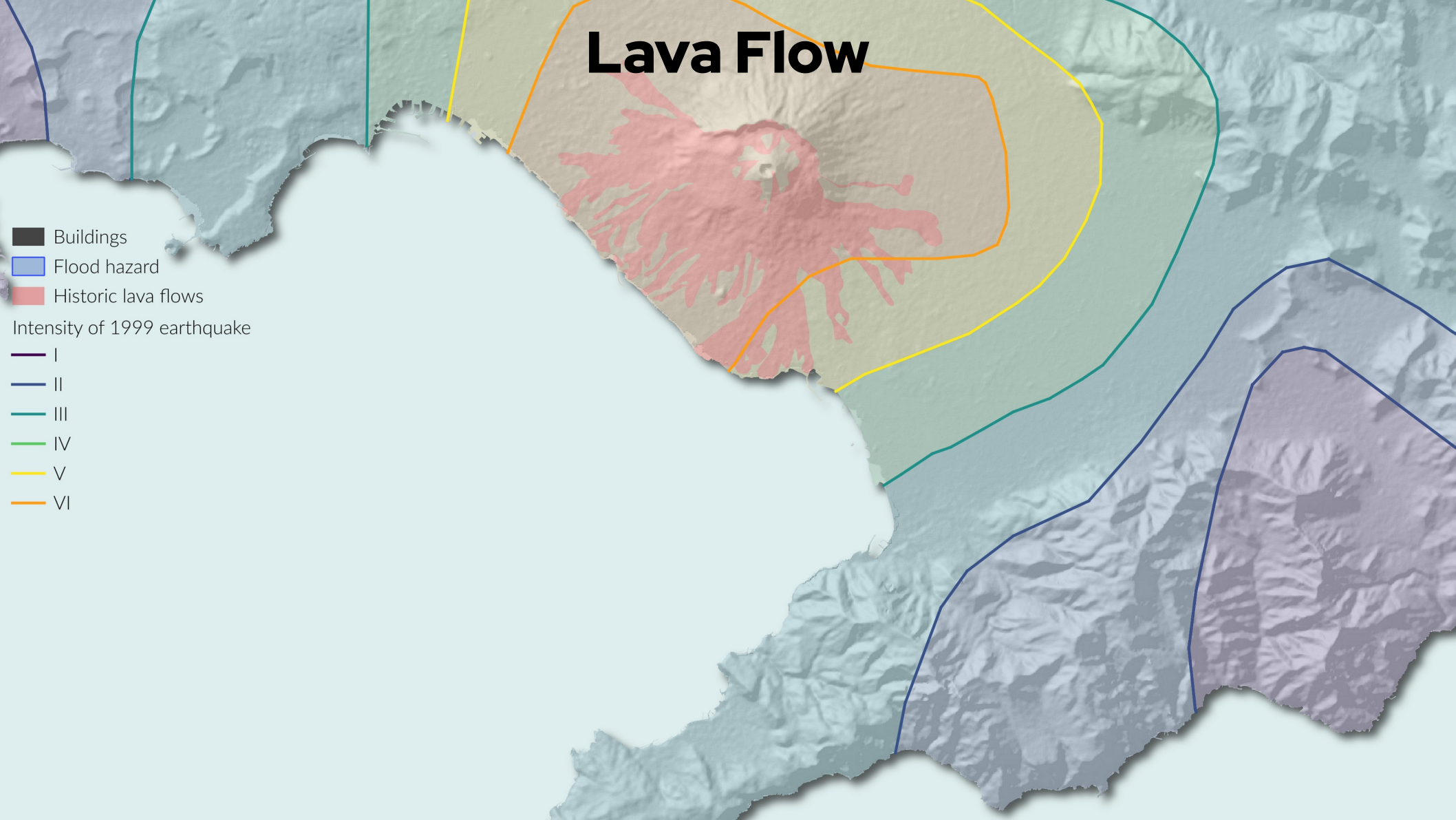
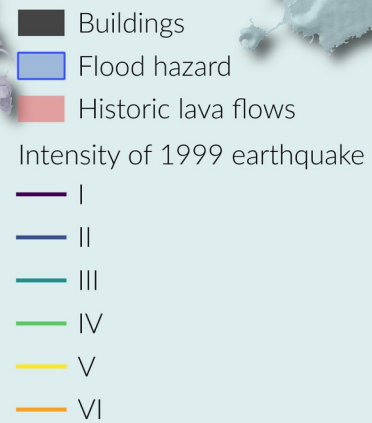
- Buildings
- Flood hazard
- Historic lava flows

Intensity of 1999 earthquake

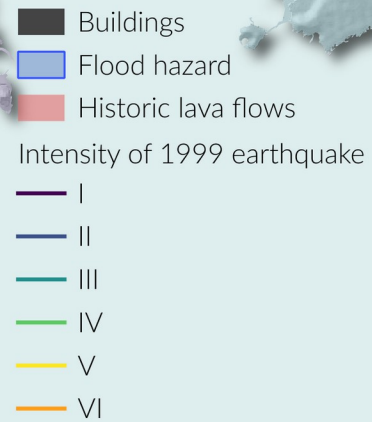
- I
- II
- III
- IV
- V
- VI



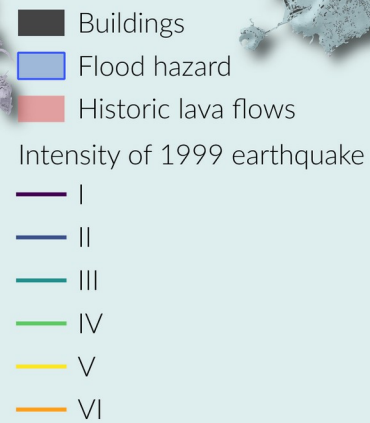
Lava Flow



Flood Hazard



Buildings



Building Details

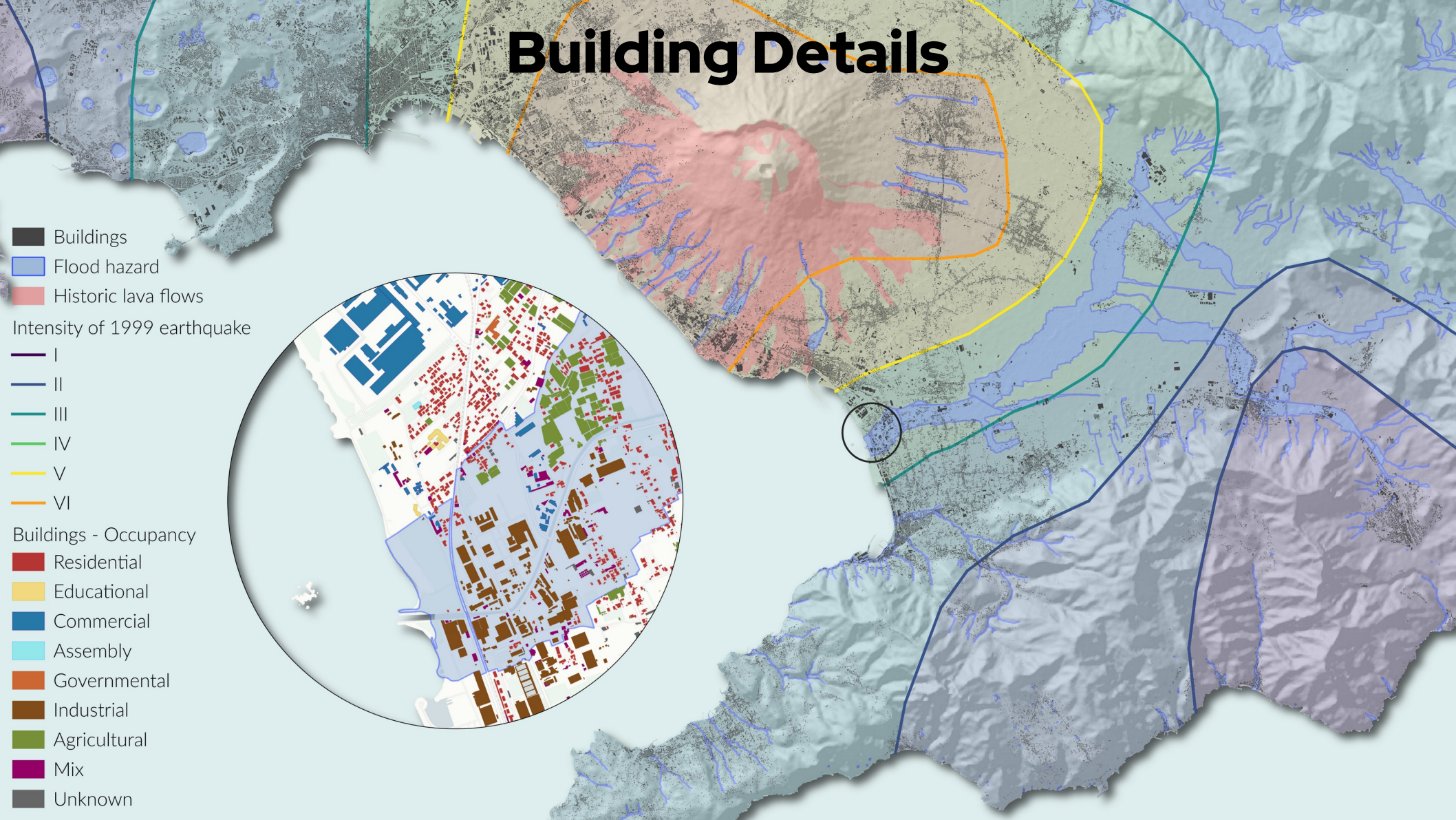
- Buildings
- Flood hazard
- Historic lava flows

Intensity of 1999 earthquake

- I
- II
- III
- IV
- V
- VI

Buildings - Occupancy

- Residential
- Educational
- Commercial
- Assembly
- Governmental
- Industrial
- Agricultural
- Mix
- Unknown



Knowing Every Building

Imagine we know every building worldwide

- Exact location & size
- Number of people inside

- Type and vulnerability
- Value



Understanding the Dynamics

From static to dynamic risk

- **Urbanization**: Cities are growing and reshaping
- **Modernization**: Building stock and values are changing
- **Time dependence**: Consecutive events (multi-hazard)



The Challenge

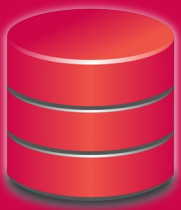
- **High-Resolution** exposure data globally
→ On the building-by-building level
- **Dynamic** exposure model for monitoring risk
→ Capturing urbanization



The Strategy

- **Crowd-sourced approach for data collection**
 - Developing a platform around the OpenStreetMap ecosystem
- **Integrating Standards**
 - Classical exposure models with standard taxonomies
- **Providing Dynamic Exposure**
 - Rule-based processing of each building separately

Data Collection



Various open data sources
Exposure models
Expert knowledge

Data Processing



Real-time updating
Data integration
Building classification

Data Dissemination



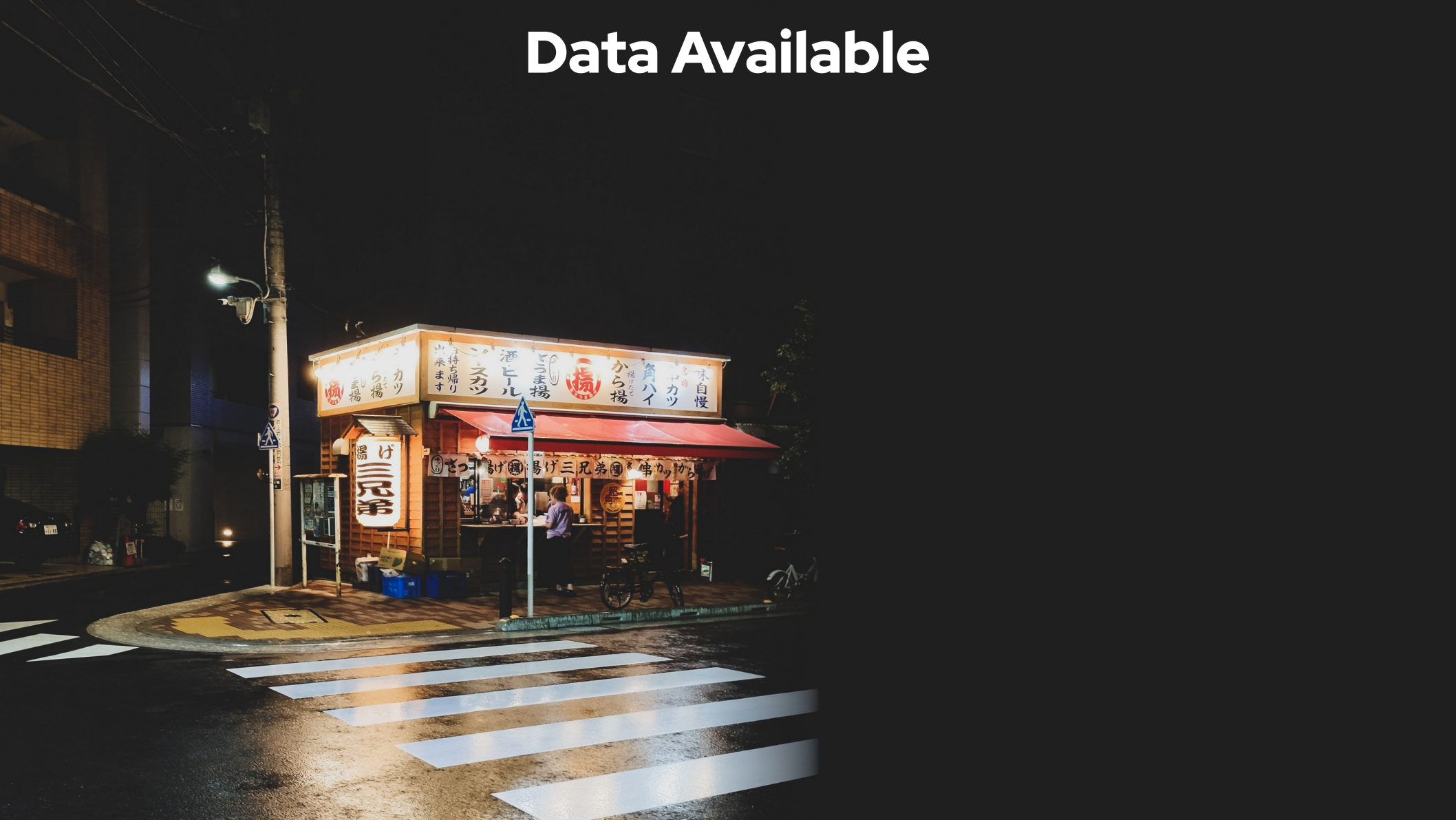
Dynamic exposure
GEM/HAZUS taxonomy
Web service/data API

Rabotnik – Assembly Line

- Key component of the processing platform
- Rule-based processing of every updated building and tile
- Leads to probabilistic selection of structural information



Data Available



Data Available

Deterministic Estimates:

- Footprint size & location



Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories



Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories
- Floor space



Data Available

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Probabilistic Estimates:

- Structural type



Data Available

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Probabilistic Estimates:

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- Structural value



Data Available

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Probabilistic Estimates:

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- Structural value
- Population



Data Available

Deterministic Estimates:

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- Number of stories
- Floor space
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Probabilistic Estimates:

- Structural type
- Structural value
- Population
- Building context



Data Available



Deterministic Estimates:

- Footprint size & location
- Number of stories
- Floor space
- Occupancy

Probabilistic Estimates:

- Structural type
- Structural value
- Population
- Building context
- Footprint shape

Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories
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Probabilistic Estimates:

- Structural type
- Structural value
- Population
- Building context
- Footprint shape
- Construction year



Data Available

Deterministic Estimates:

- Footprint size & location
- Number of stories
- Floor space
- Occupancy

Probabilistic Estimates:

- Structural type
- Structural value
- Population
- Building context
- Footprint shape
- Construction year
- Roof shape



Processing

- Updating from OpenStreetMap every 60 seconds
- Processing all changes
- Algorithmically assessing all possible building properties



Global Dynamic Exposure

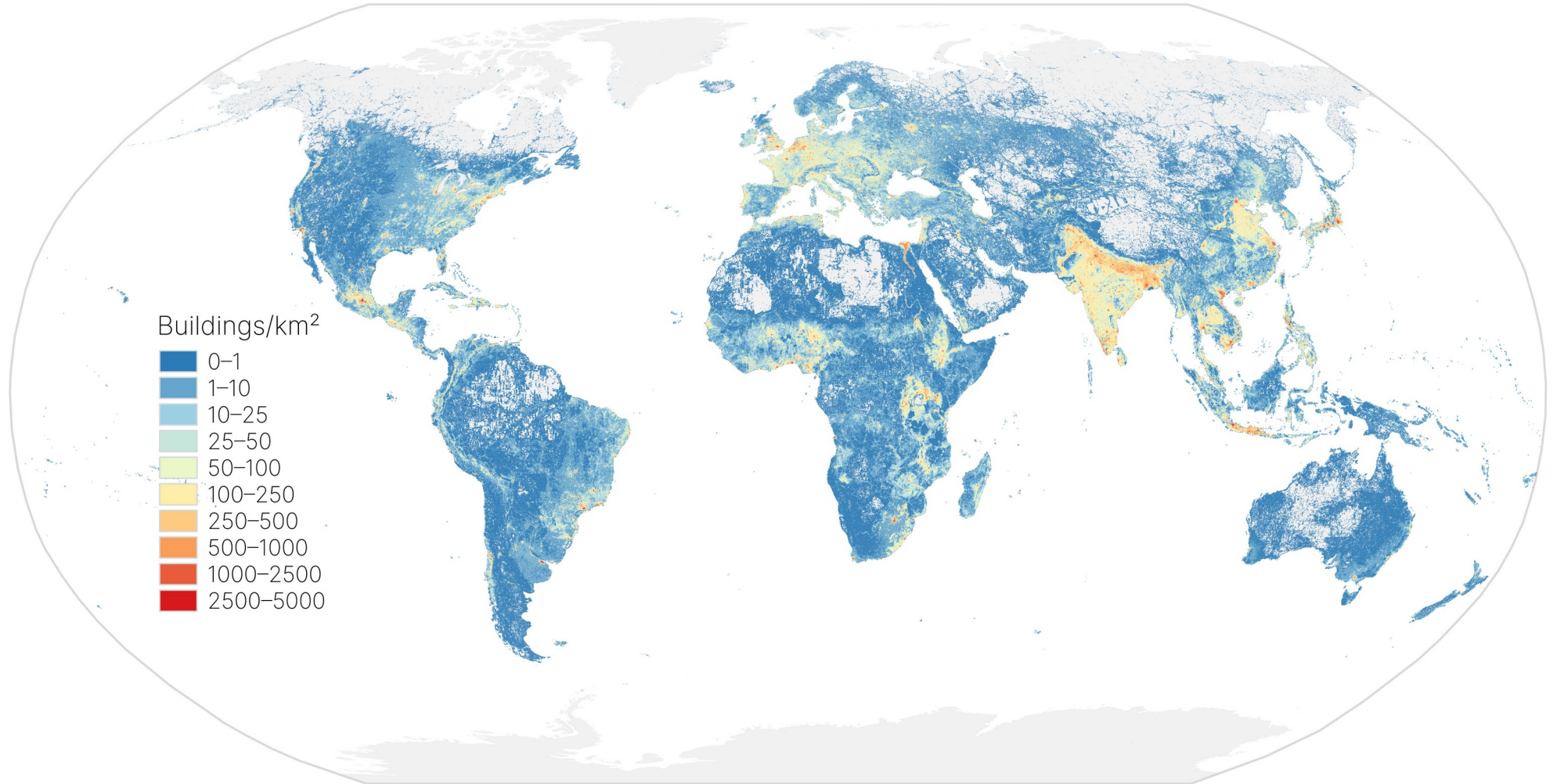


OpenBuildingMap today:

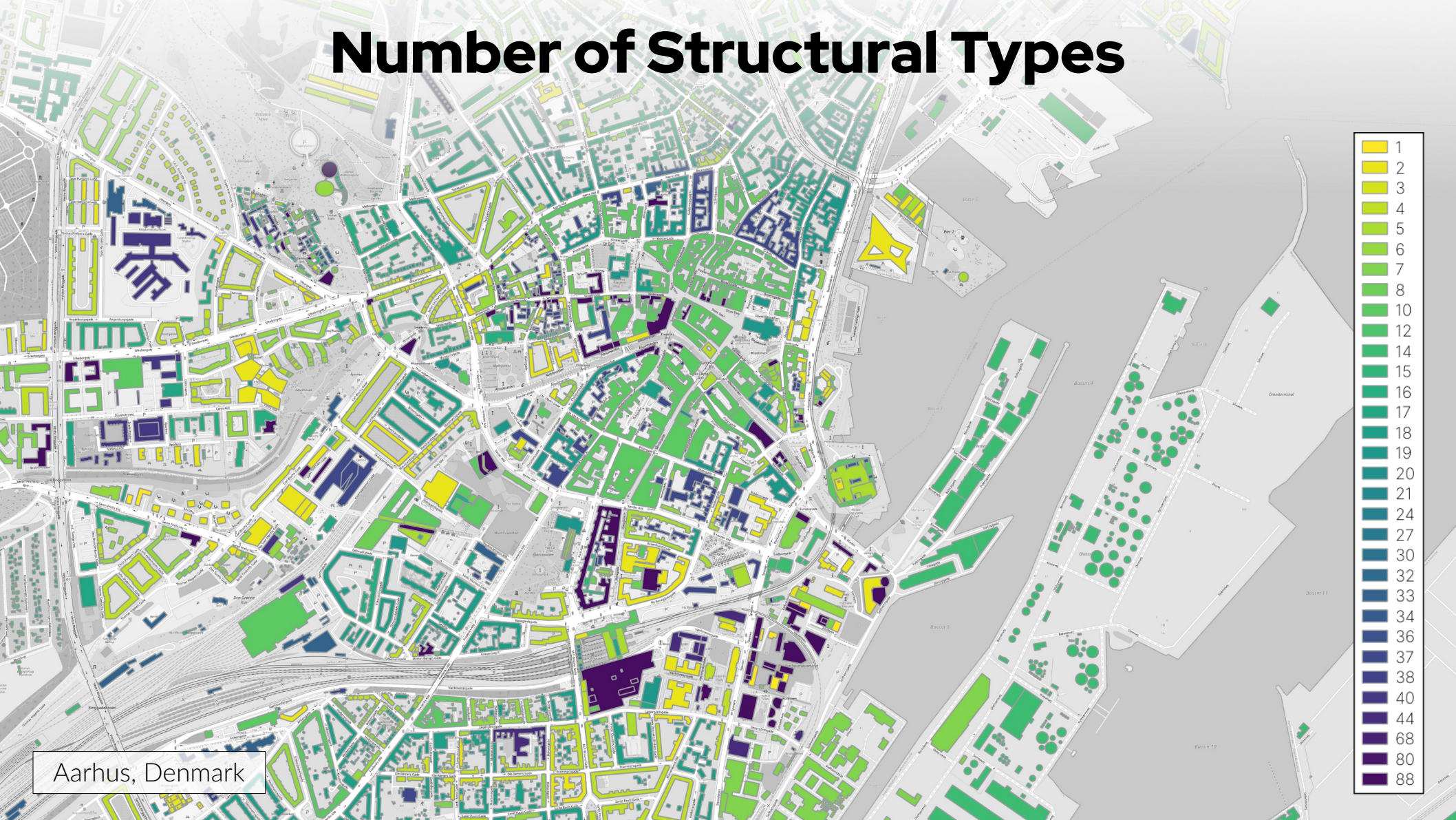
~2.7 billion building datasets

5+ million building footprints added every month (**> 2** per second)

Number of Buildings

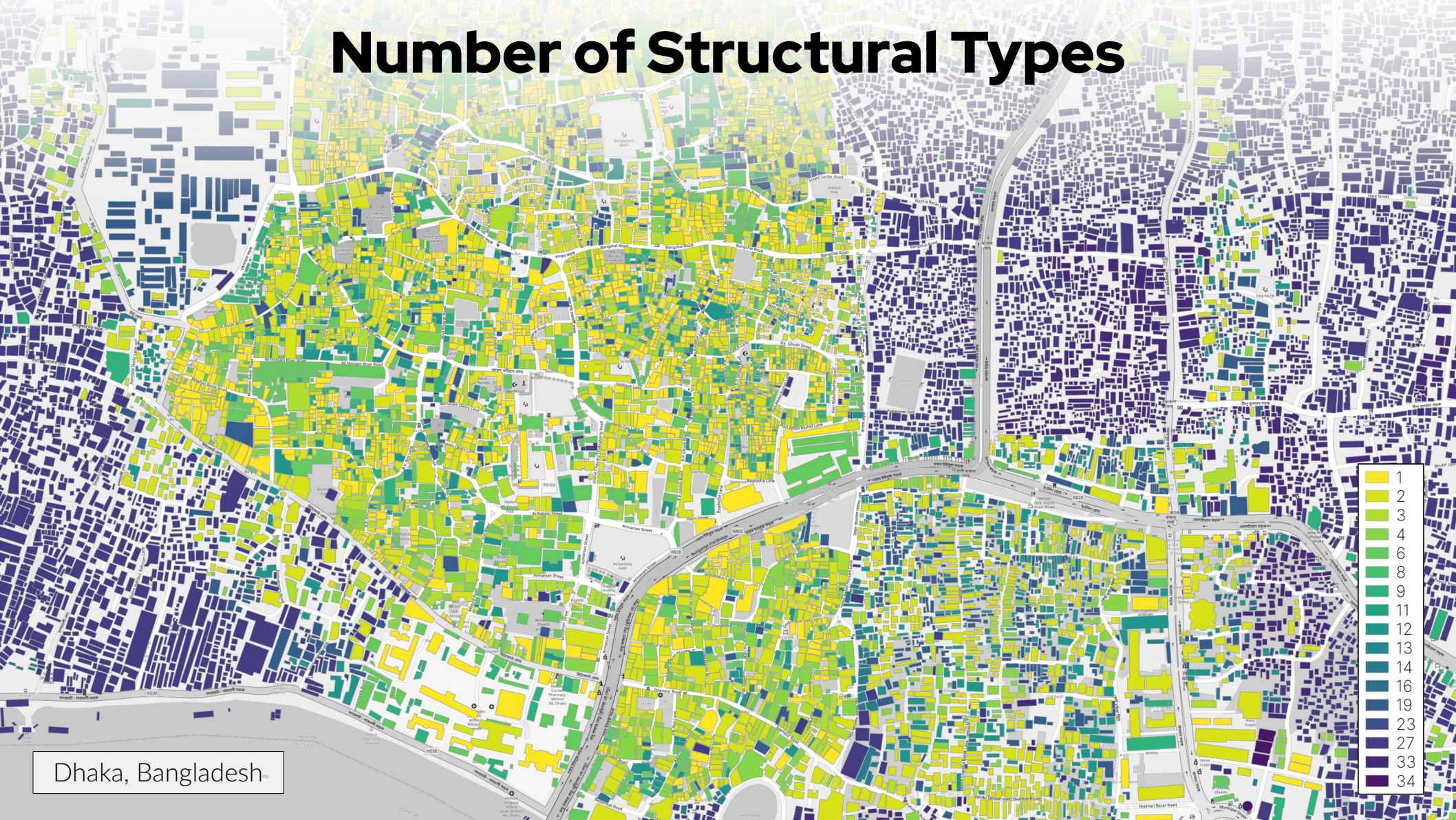


Number of Structural Types



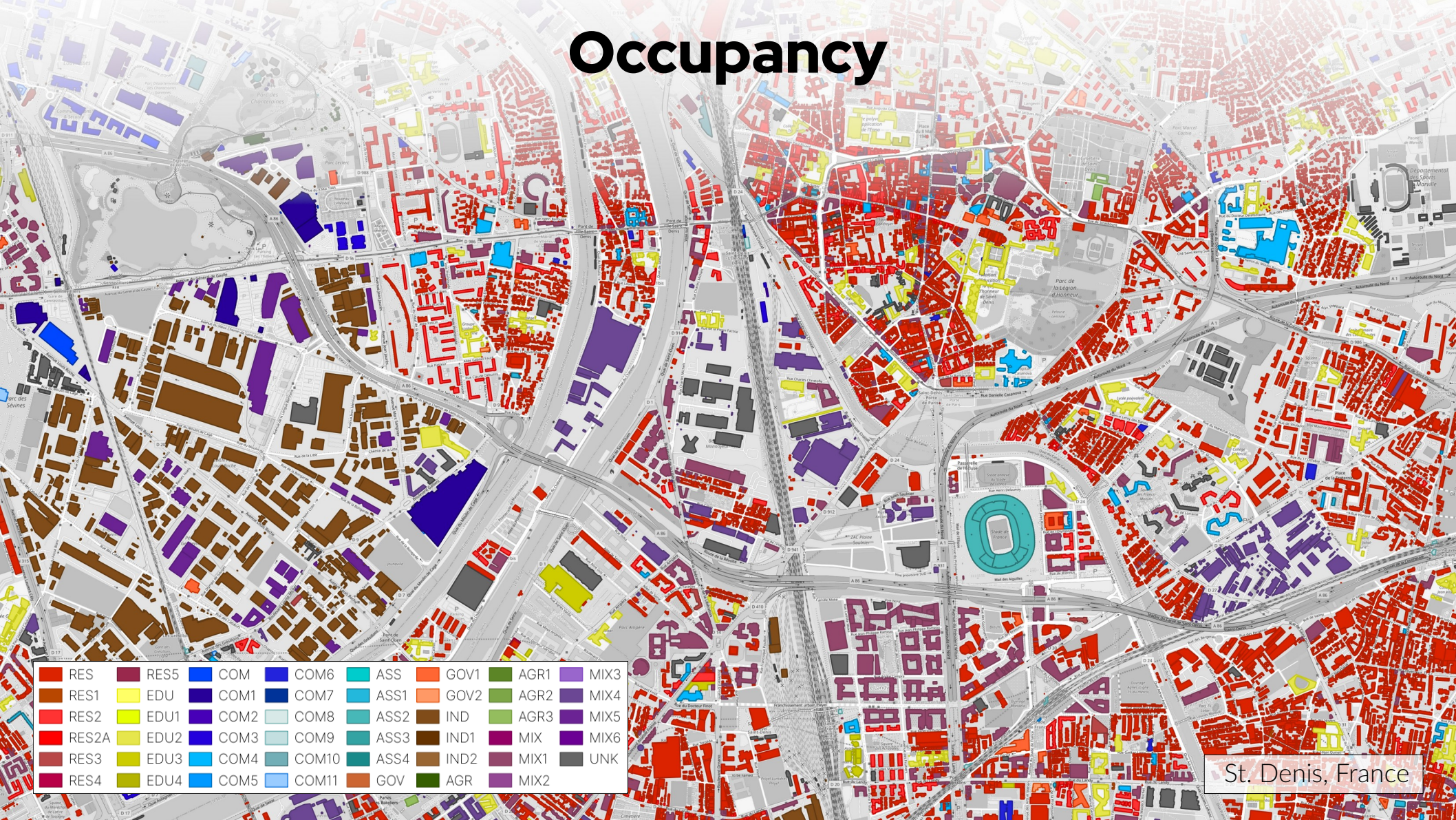
Aarhus, Denmark

Number of Structural Types



Dhaka, Bangladesh

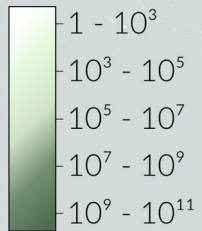
Occupancy



St. Denis, France

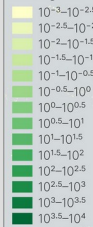
Structural Value

Structural Value (USD)

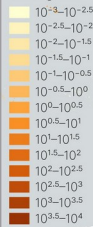


Material

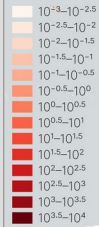
Earth and adobe buildings/km²



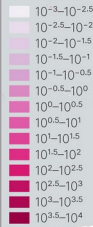
Wood buildings/km²



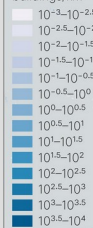
Masonry buildings/km²



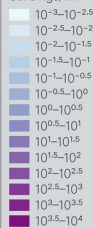
Unreinforced masonry buildings/km²



Steel and metal buildings/km²

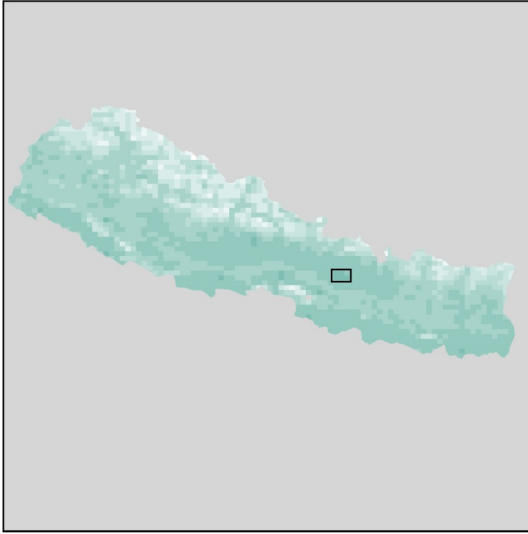
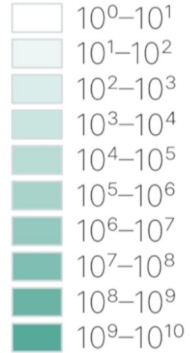


Concrete buildings/km²

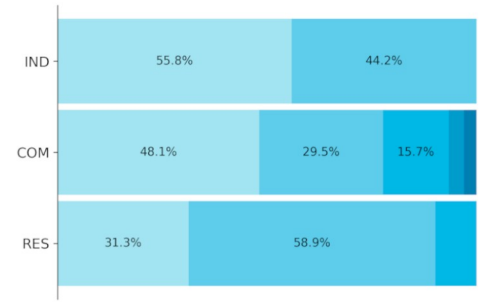
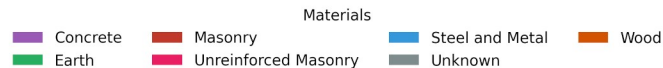
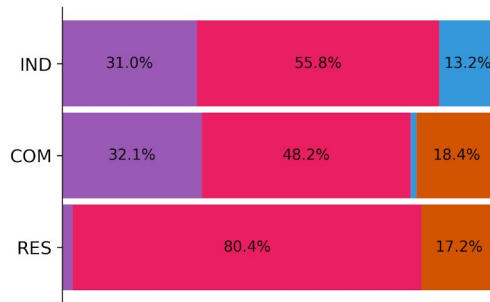
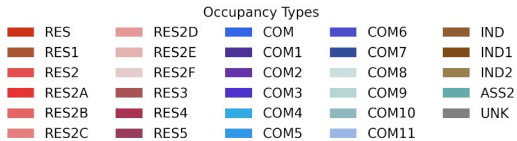
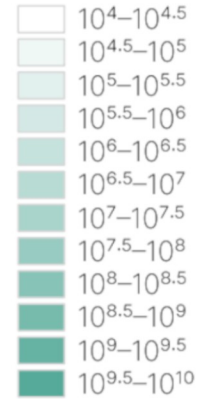


Country Summary – Nepal

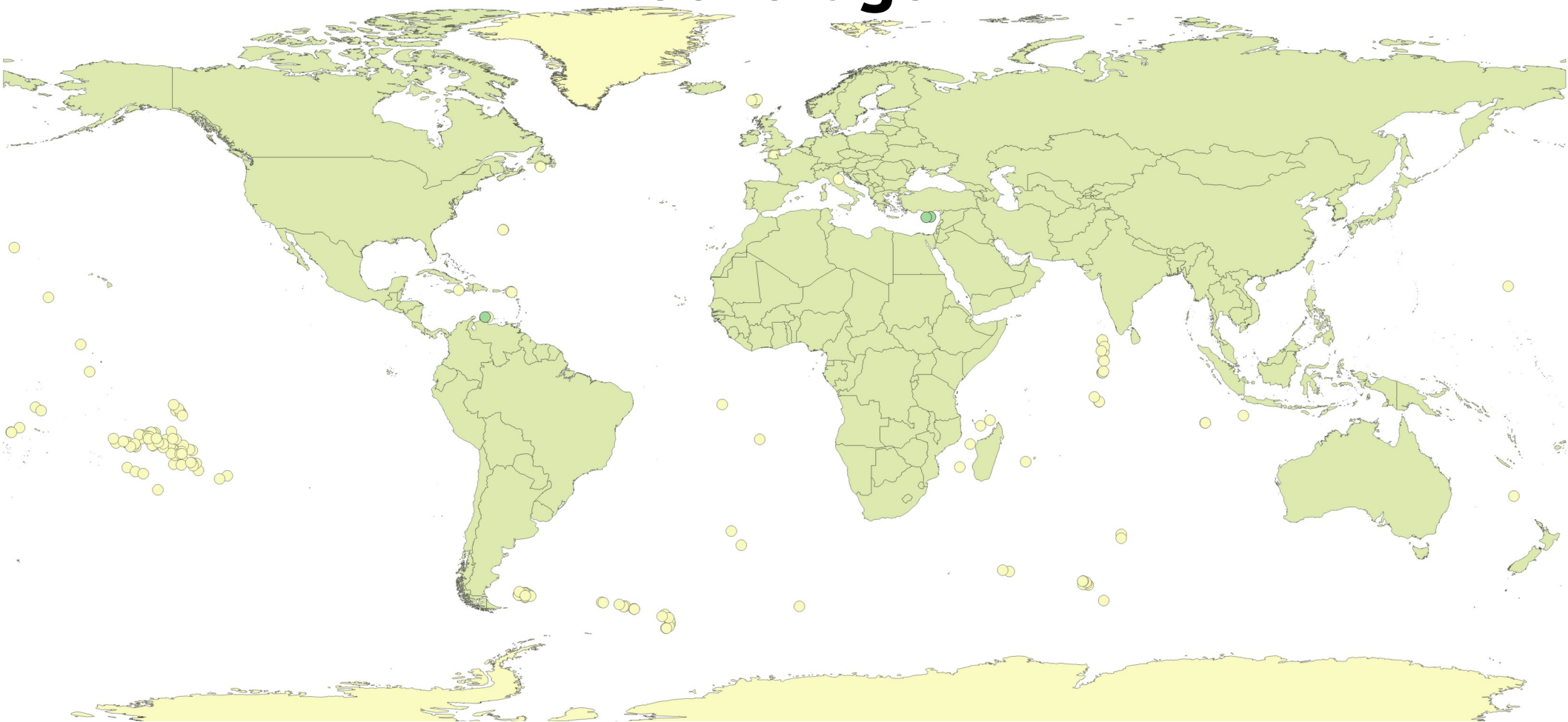
Structural value
US dollars/km²



Structural Value
US dollars/km²



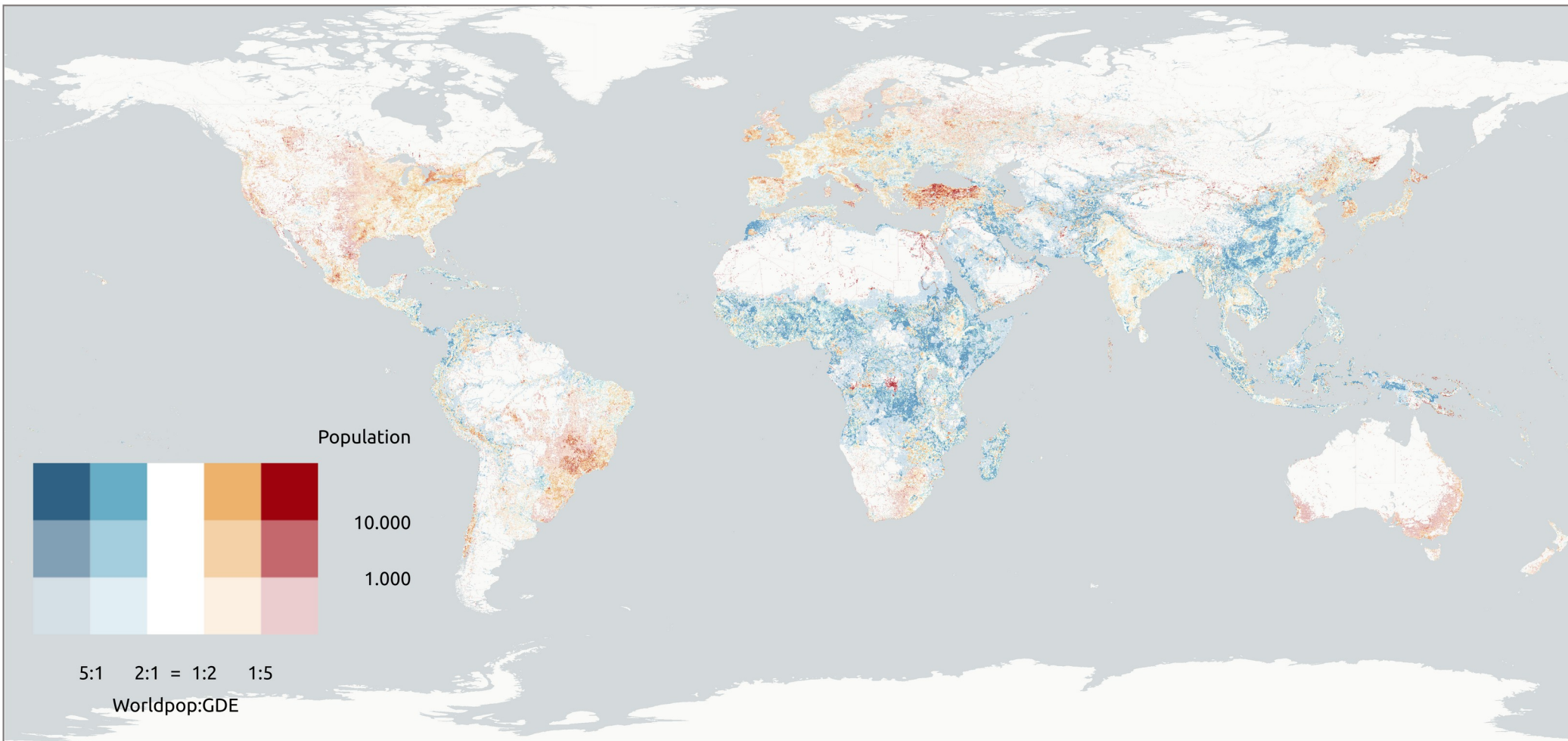
Coverage



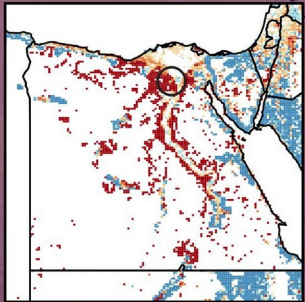
Fully covered with structural information ( using structural information from neighboring country)

Covered without structural information (only buildings and population distribution)

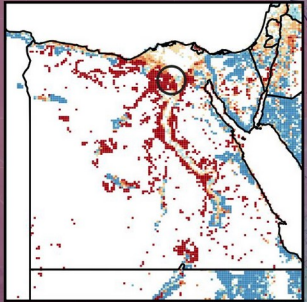
Validation



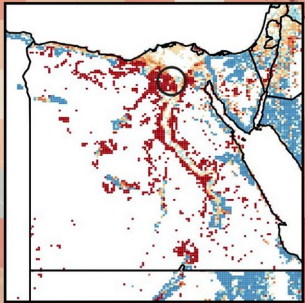
Worldpop



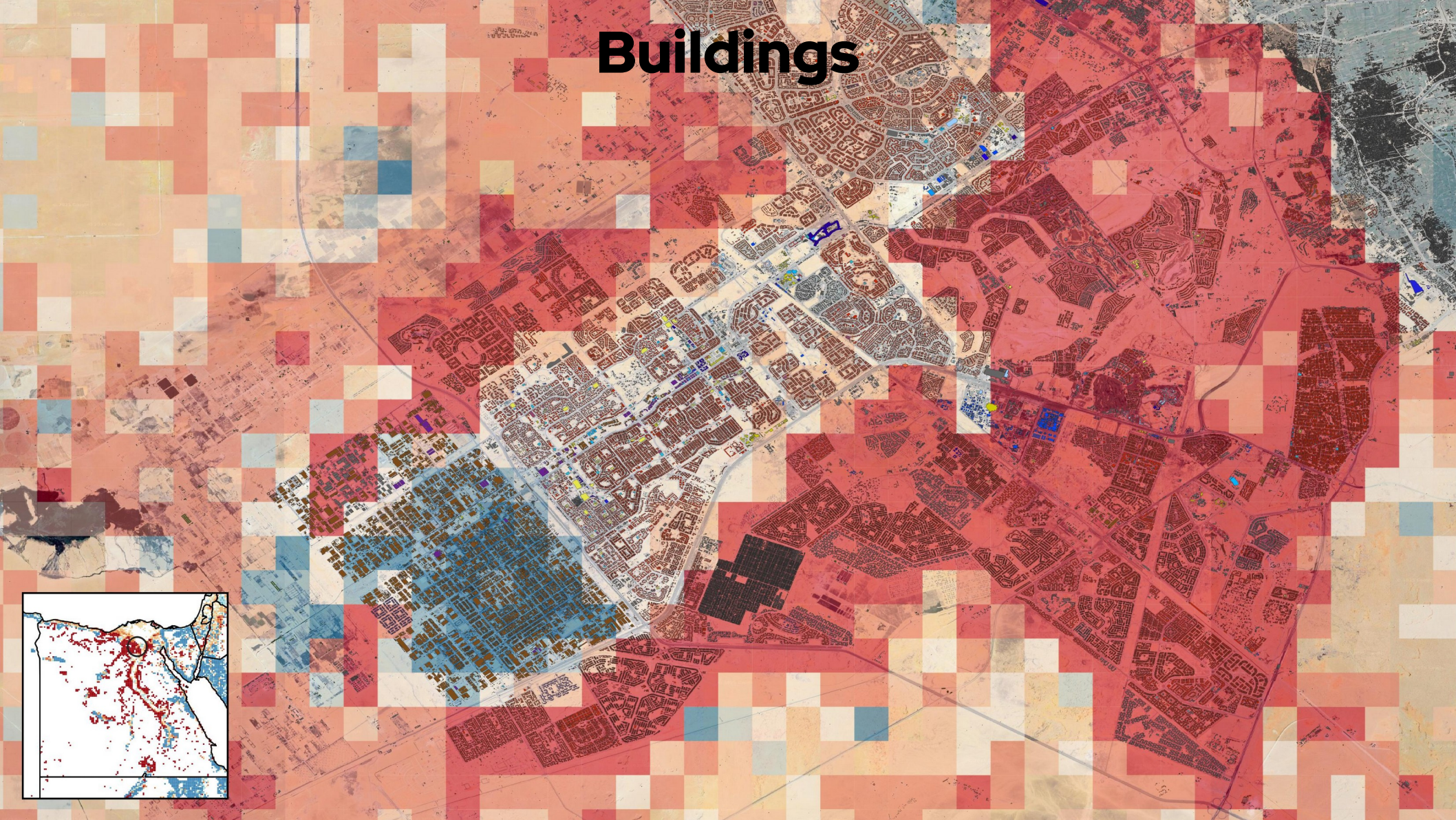
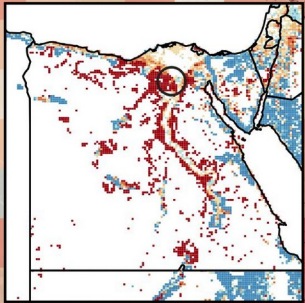
Global Dynamic Exposure



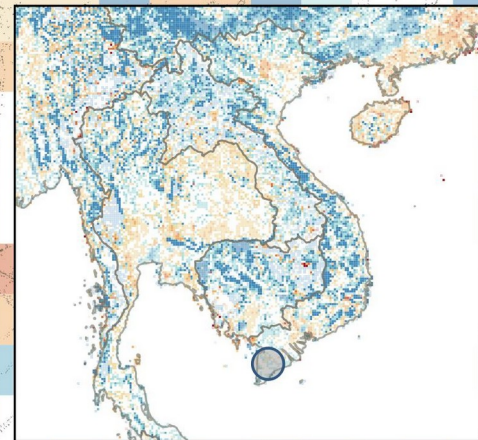
Difference



Buildings

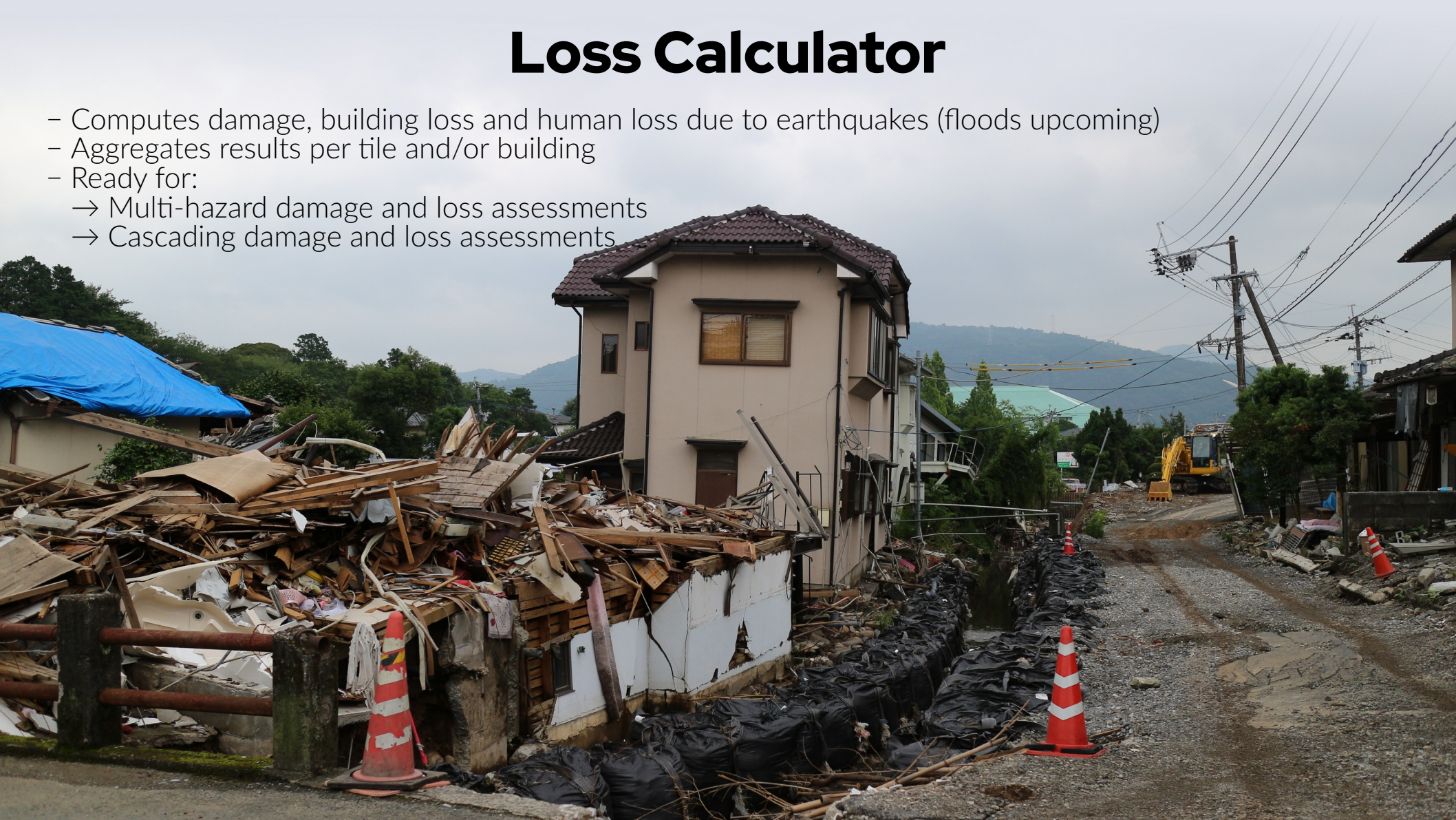


Vietnam

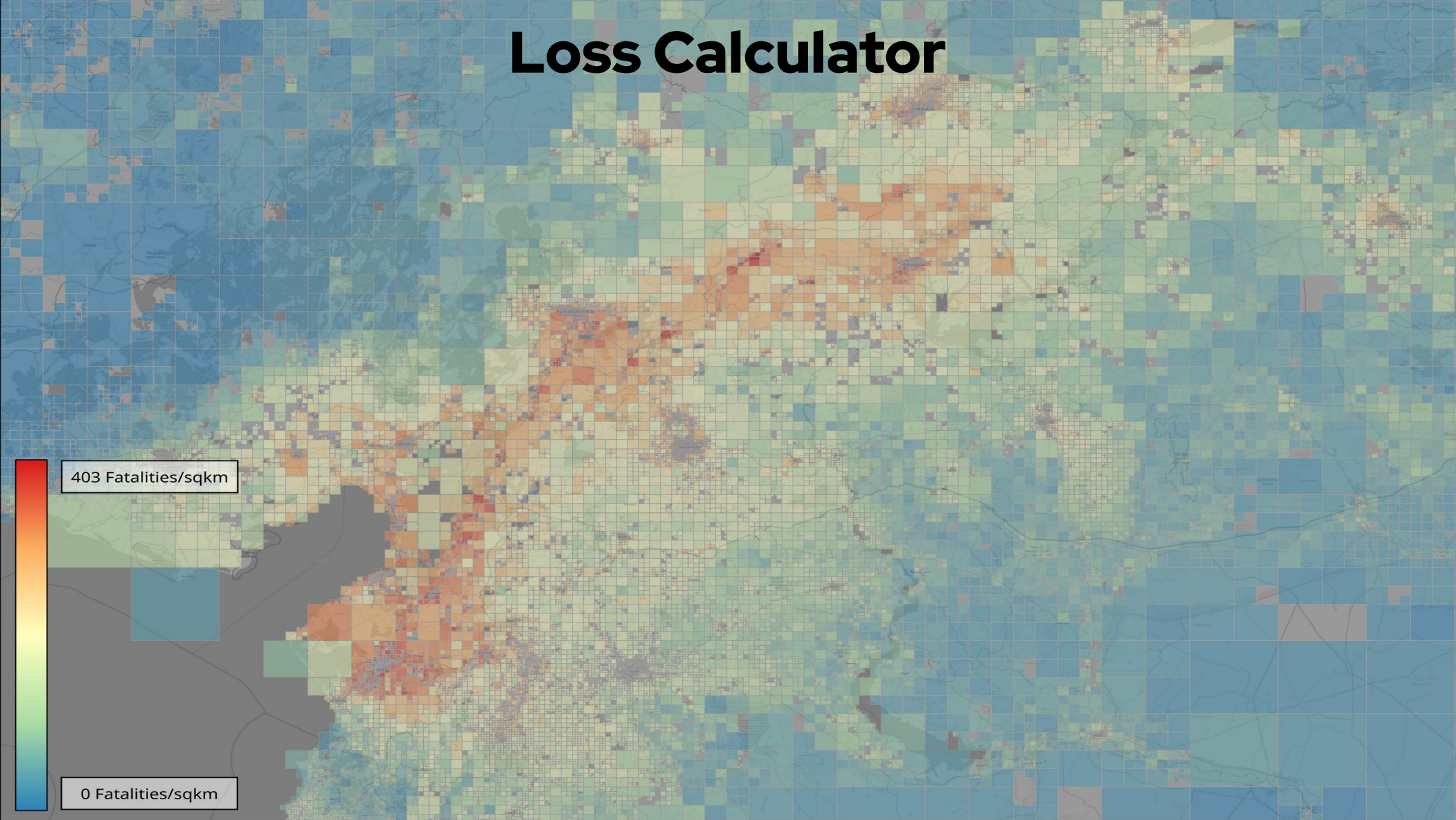


Loss Calculator

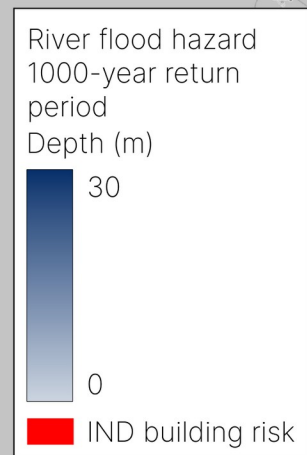
- Computes damage, building loss and human loss due to earthquakes (floods upcoming)
- Aggregates results per tile and/or building
- Ready for:
 - Multi-hazard damage and loss assessments
 - Cascading damage and loss assessments



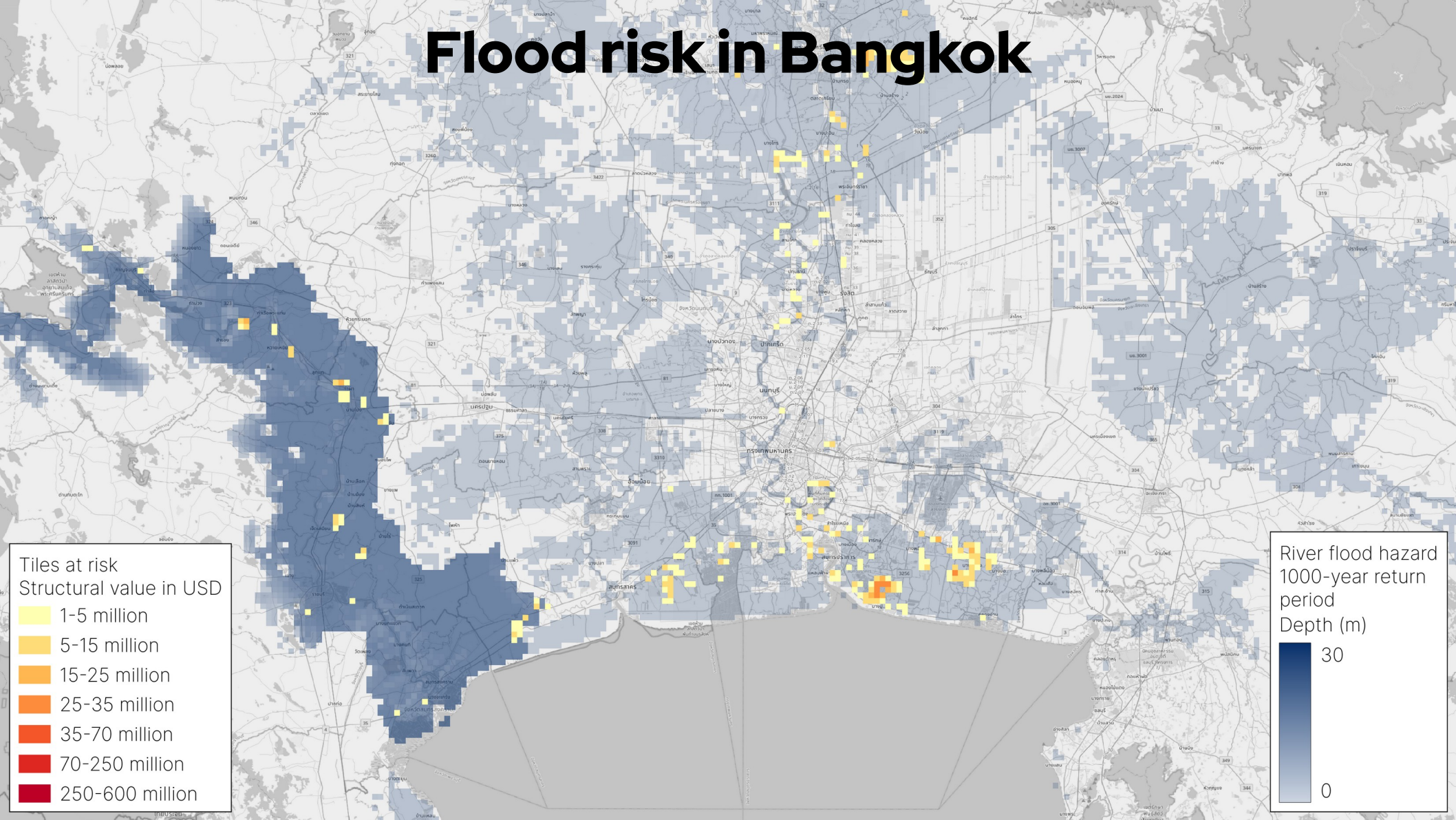
Loss Calculator



Flood risk in Southeast Asia



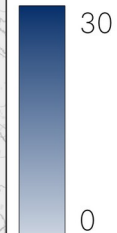
Flood risk in Bangkok



Tiles at risk
Structural value in USD

- 1-5 million
- 5-15 million
- 15-25 million
- 25-35 million
- 35-70 million
- 70-250 million
- 250-600 million

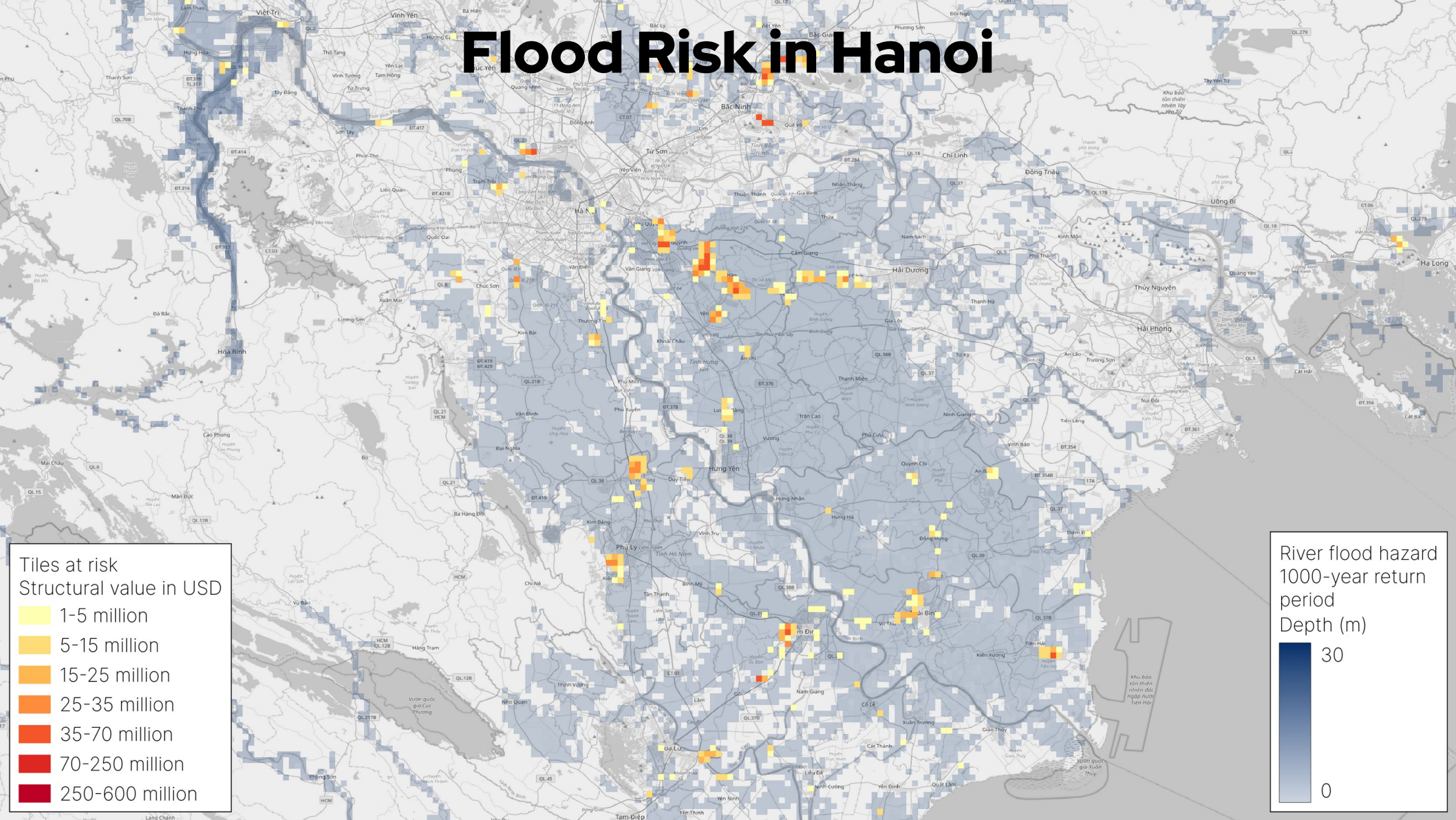
River flood hazard
1000-year return
period
Depth (m)



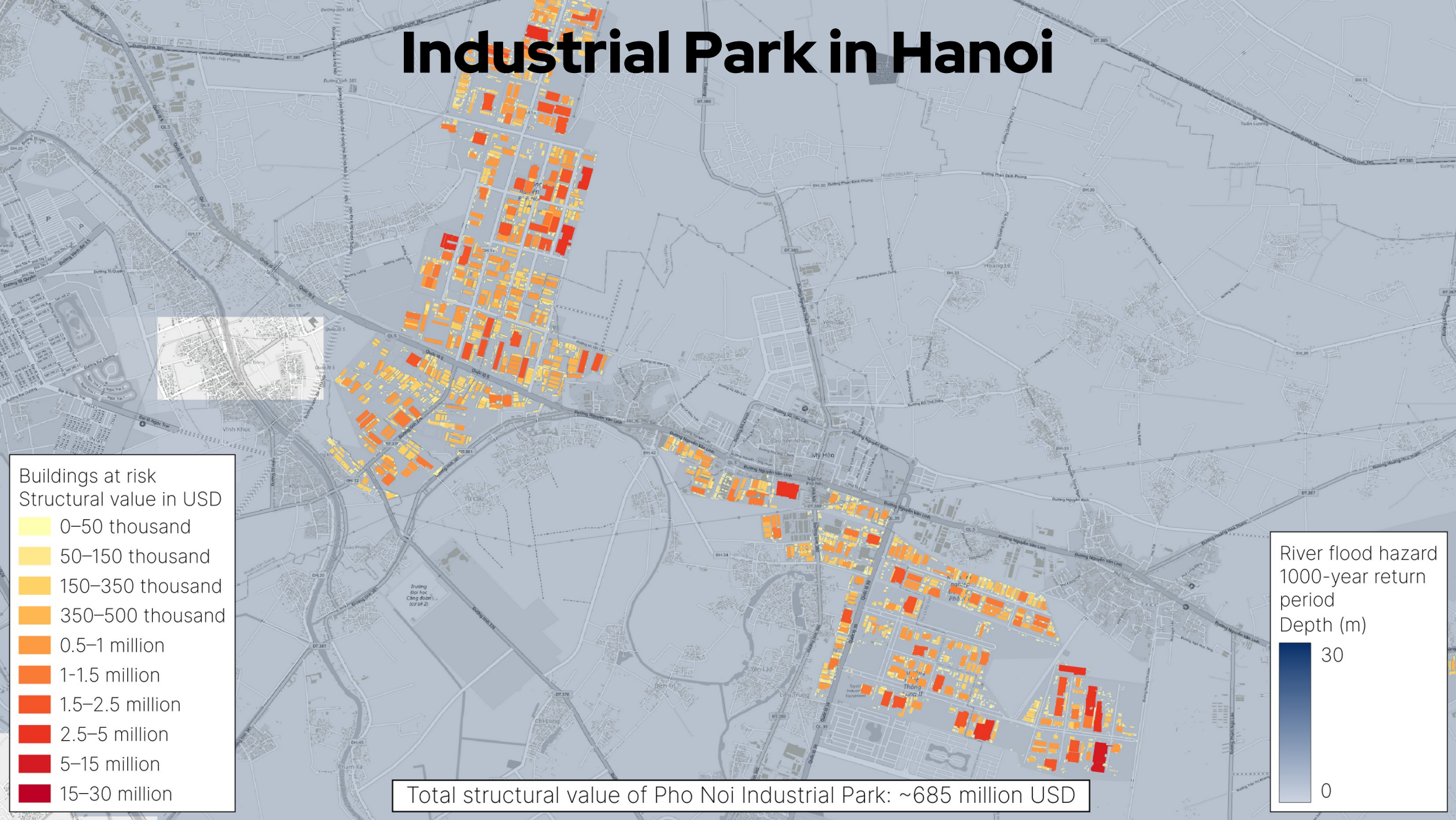
Industrial park in Bangkok



Flood Risk in Hanoi



Industrial Park in Hanoi



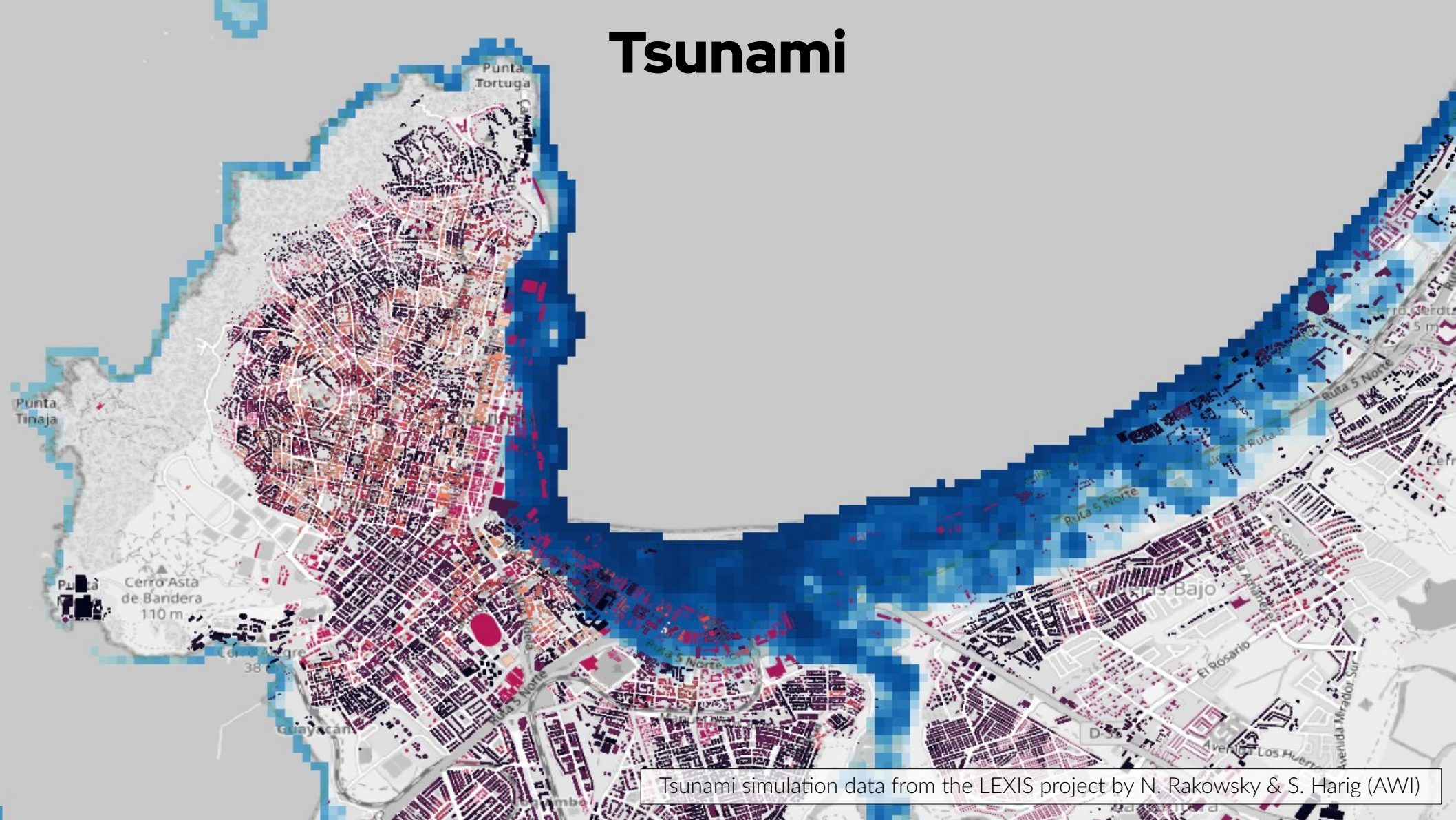
Coquimbo, Chile 2015



Expected Earthquake Damage



Tsunami



Tsunami simulation data from the LEXIS project by N. Rakowsky & S. Harig (AWI)

Where are the People?

- Add people outside of buildings to the exposure model
 - Public places, e.g. squares, parks, busy streets
 - Beaches
- Implement daily, weekly, seasonal variations



Exposure for Multi-Hazard



Exposure for Multi-Hazard



Exposure for Multi-Hazard



Tabula Taxonomy



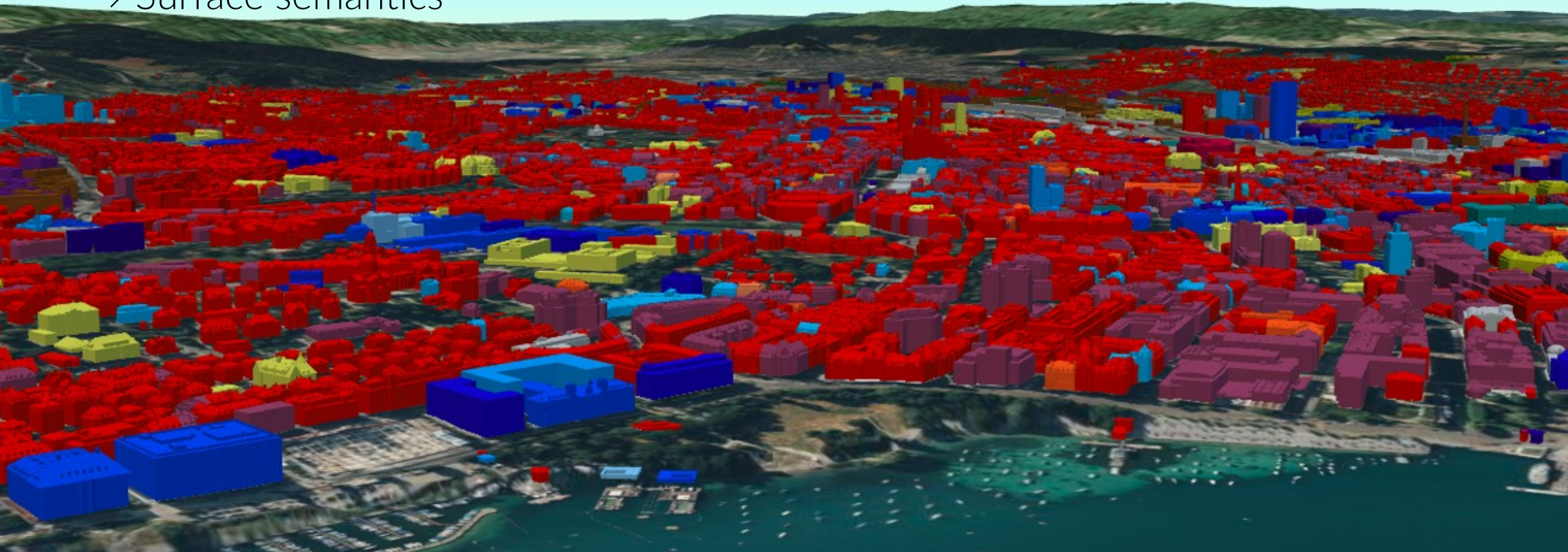
LOSS MODELLING
FRAMEWORK

Tabula Classification

- ES.ME.AB.01.Gen
- ES.ME.AB.02.Gen
- ES.ME.AB.03.Gen
- ES.ME.AB.04.Gen
- ES.ME.AB.05.Gen
- ES.ME.AB.06.Gen
- ES.ME.MFH.01.Gen
- ES.ME.MFH.02.Gen
- ES.ME.MFH.03.Gen
- ES.ME.MFH.04.Gen
- ES.ME.MFH.05.Gen
- ES.ME.MFH.06.Gen
- ES.ME.SFH.01.Gen
- ES.ME.SFH.02.Gen
- ES.ME.SFH.03.Gen
- ES.ME.SFH.04.Gen
- ES.ME.SFH.05.Gen
- ES.ME.SFH.06.Gen
- ES.ME.TH.01.Gen
- ES.ME.TH.02.Gen
- ES.ME.TH.03.Gen
- ES.ME.TH.05.Gen
- ES.ME.TH.06.Gen
- Non-residential

3D Buildings

- To be provided by the EU for up to 500 cities in the member states
- Further data coming from the Japan Plateau dataset, USA, etc.
- Contains:
 - Up to LoD2.2 details
 - Surface semantics



The Way Forward

- Bringing the model to market while keeping it free for humanitarian/research use
- Update the model constantly and continue the research to improve the model
- Increase the coverage of 2.5D and 3D building data and add new datasets
- Employ AI techniques to increase the coverage of properties



Thank You

Contact: ds@gfz.de



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Slide 57: “A long road ahead” by Milton (<https://www.flickr.com/photos/83593704@N06/27950878631/>)

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