The spatial distribution of the resident population and the “Degree of Urbanisation” in the GHSL R2023

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Structure & Outline

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  - Why
  - How
- The GHSL population grid: GHS-POP R2023A
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  - Workflow
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- The Degree of Urbanisation
  - What is
  - Why
  - How
- The porting of the Degree of Urbanisation into the GHSL framework: GHS-SMOD and GHS-DUC R2023A

The population grid

What is

Why

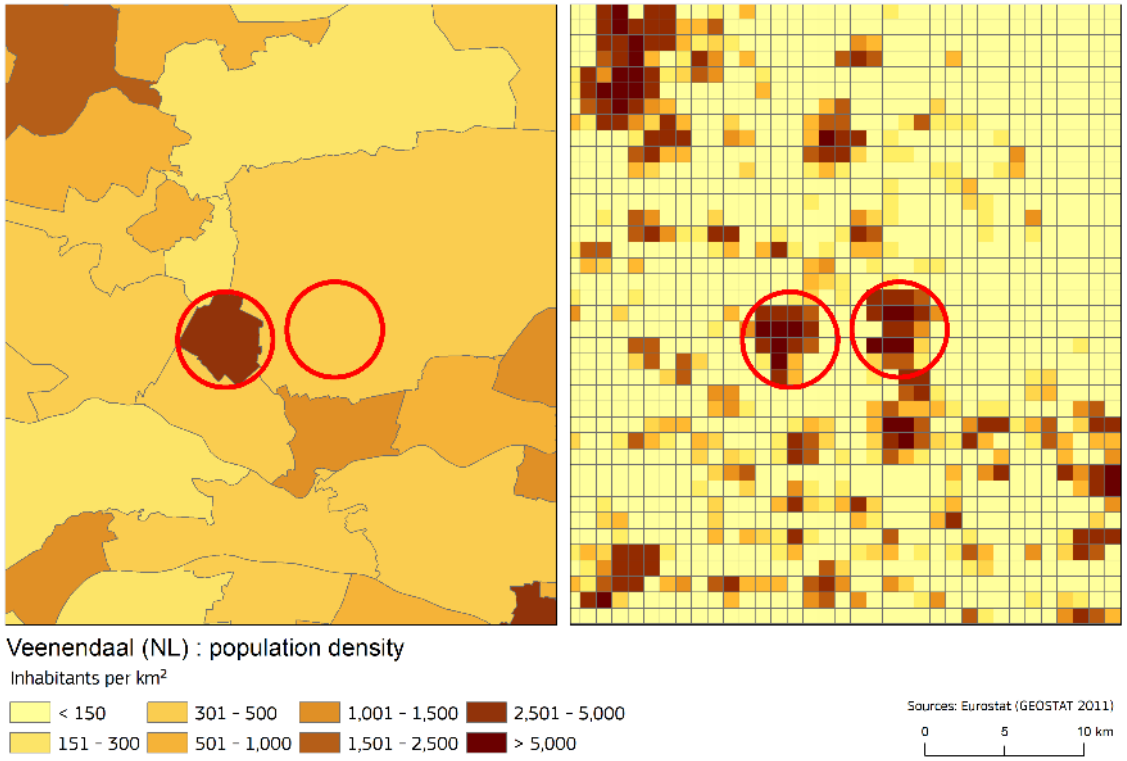
How

The population grid: What is

- A population grid is a representation of the population distribution on a regular grid usually in raster format or vector format
  - Resident population
  - Temporary population (e.g. commuters)
  - …

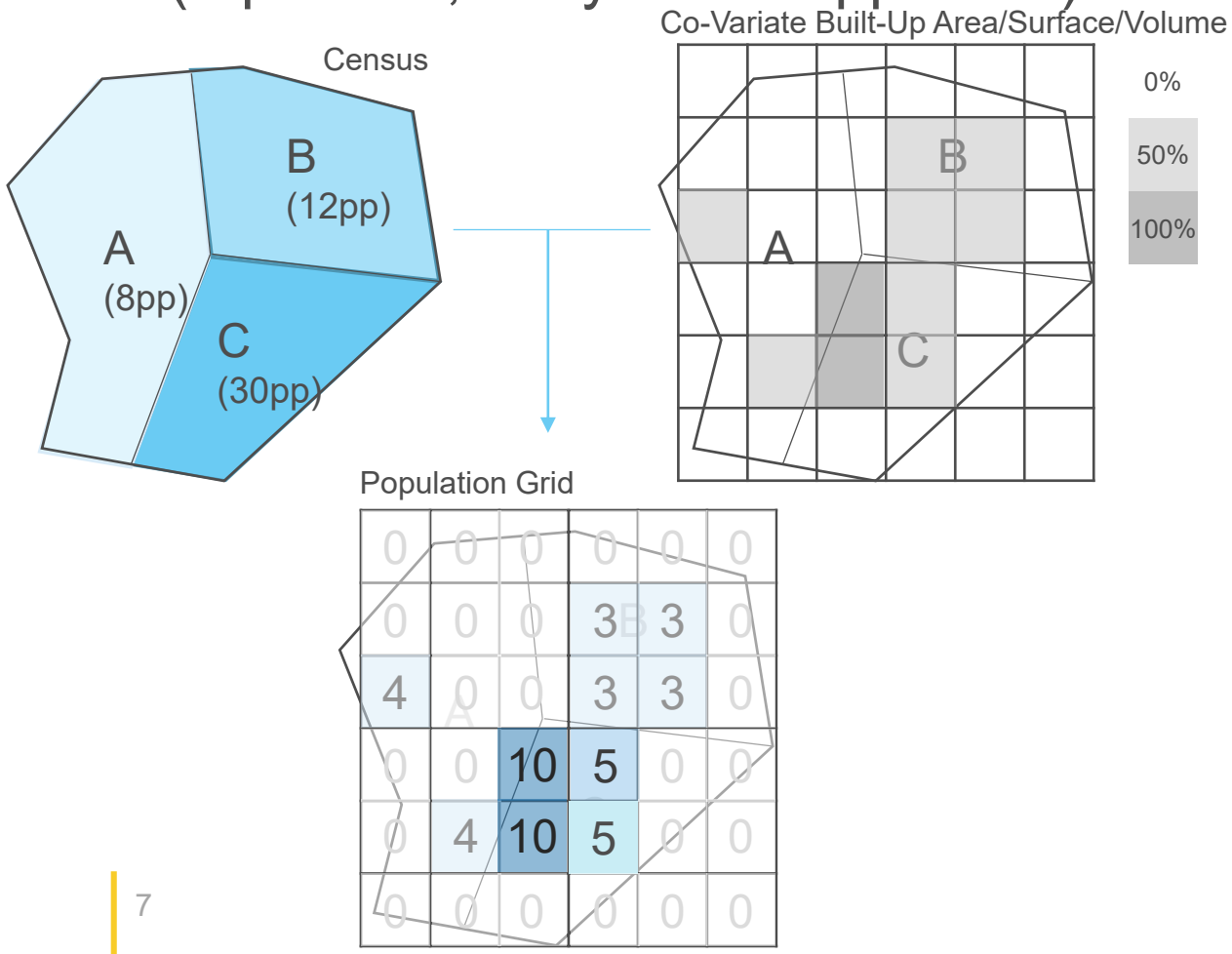
The population grid: Why

- Does not depend on the shape and size of census units
- Does not depend on the boundary of census units
- Grid cells have the same size and are stable over time
- Grids integrate easily with other data
- Grid cells can be assembled into custom zones

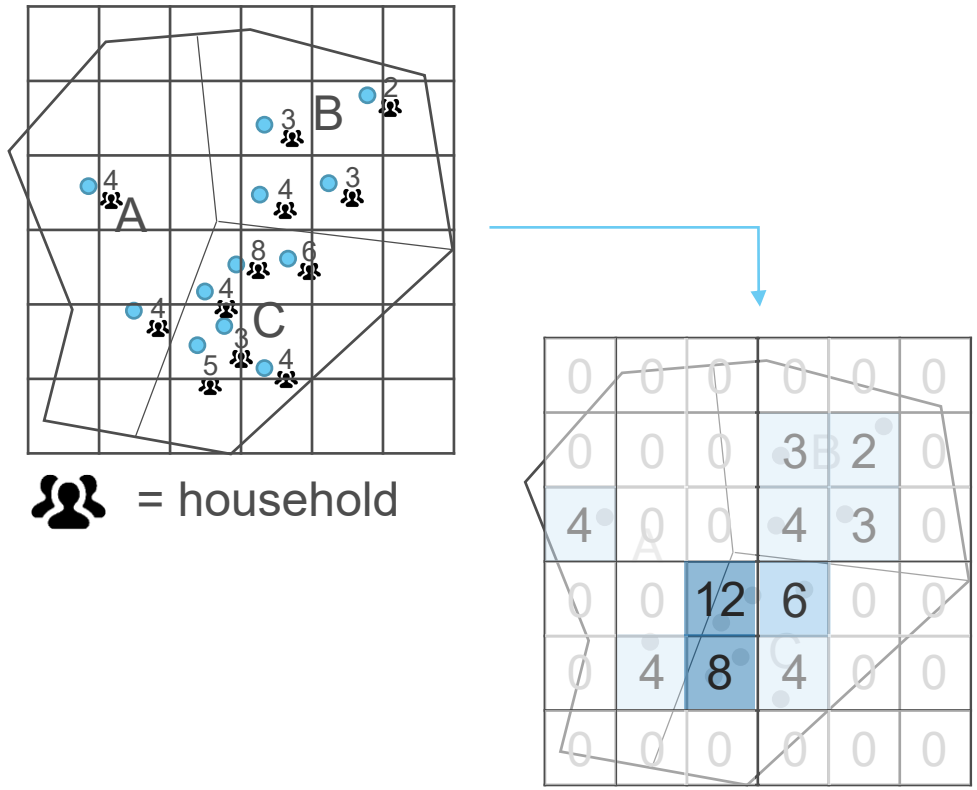


The population grid: How

- Census disaggregation (top-down, dasymetric approach)



- Census aggregation (bottom-up)



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The GHSL population grid: GHS-POP R2023A

Input data

Workflow

Multi-temporal population estimates

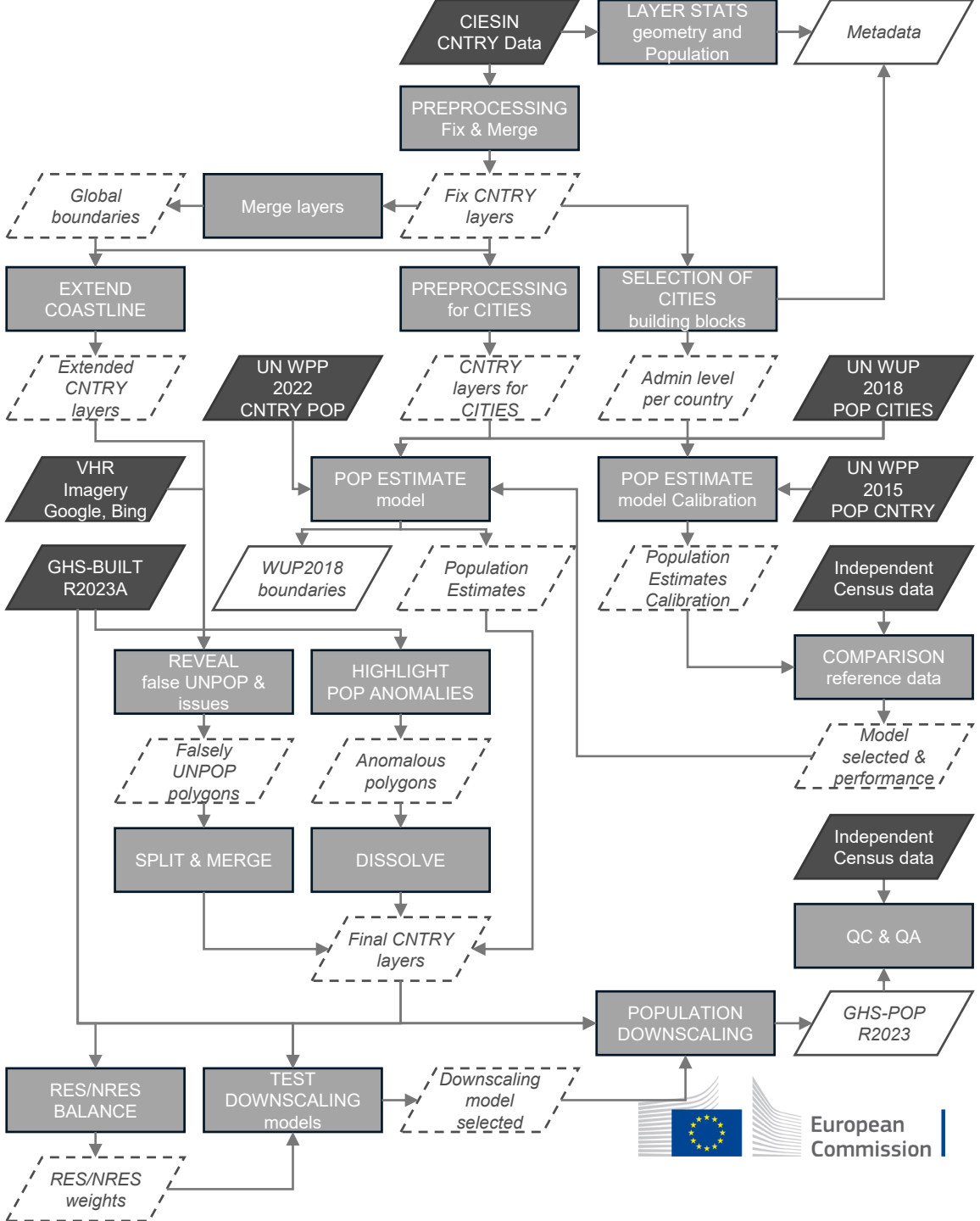
Covariate selection

GHS-POP R2023A: Input data

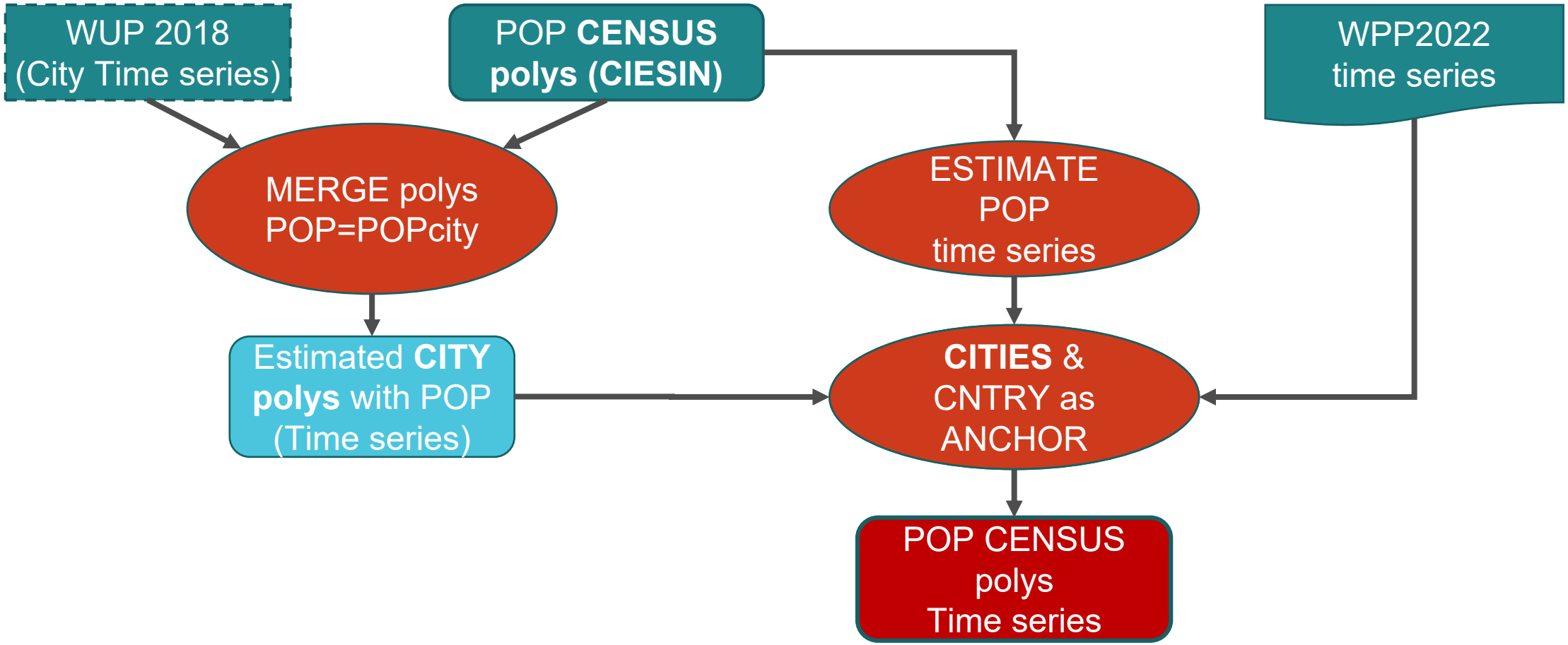
- Resident population data (census) collected by the Center for Integrated Earth System Information (CIESIN, Columbia University, NY) for the production of the Gridded Population of the World (GPW v4.11):
  - 251 Countries
  - 13,415,003 polygons
  - Harmonised geometries
  - 2 Census epochs per country (2000-2010 on average, ranging between 1983 and 2015)
  - Adjusted growth rates computed between the two epochs
- UN World Population Prospects 2022 (WPP2022)
  - Countries population time series (to adjust country total annual population)
- UN World Urbanisation Prospects 2018 (WUP2018)
  - Urban Agglomerations population time series (increase the accuracy of estimates)
- GHSL built-up layers as covariates (Surface/Volume; TOT/NRES) [disaggregation top-down approach]

GHS-POP R2023A: Workflow

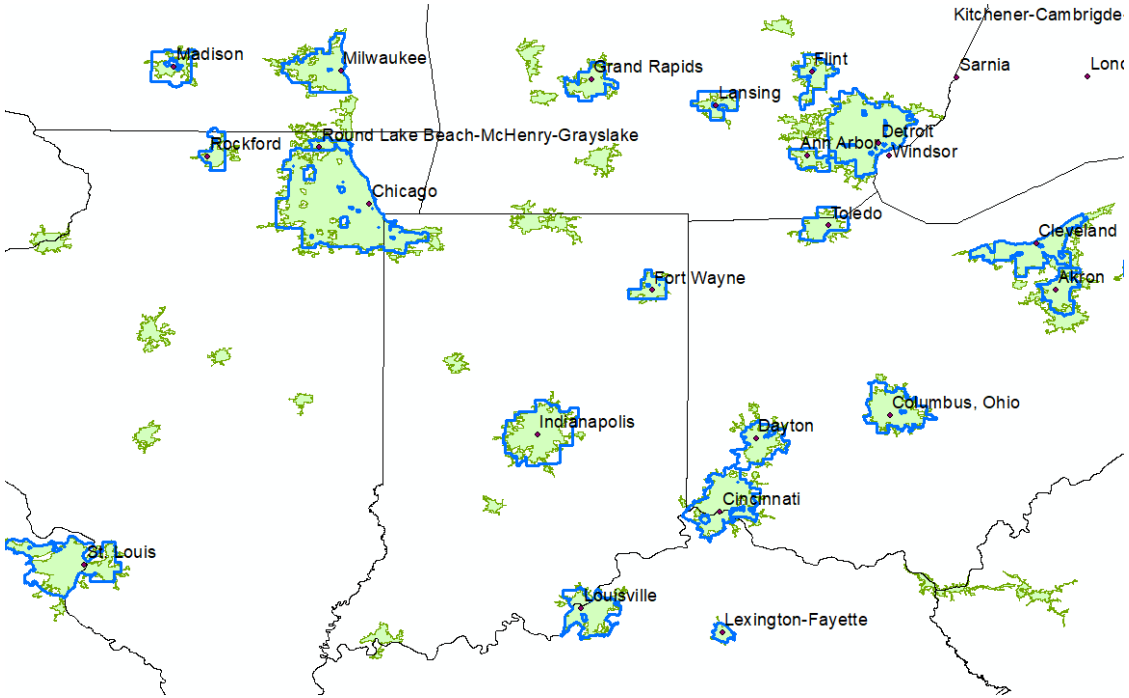
- Data Statistics
- Layer Pre-processing
- Multi-temporal population estimates (1975-2030 5yrs interval)
- Coastline extension
- Falsely unpopulated polygons & Population data anomalies
- Identification of the best covariate
- Population downscaling
- Quality check and assessment

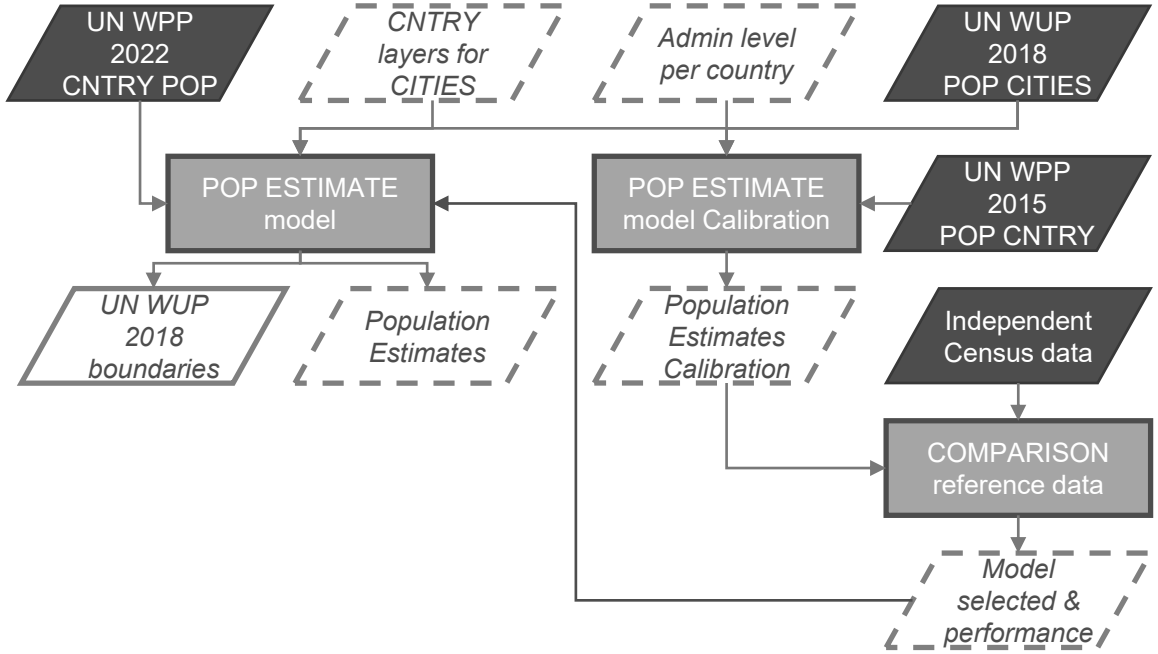


GHS-POP R2023A:
Multi-temporal population estimates (1)



GHS-POP R2023A:
Multi-temporal population estimates (2)





Blue: estimated boundaries
(SmartDissolve, *Schiavina et al. 2023,* http://dx.doi.org/10.1038/s41598-023-31253-z)
Green: 'city' boundaries in US, from UN data

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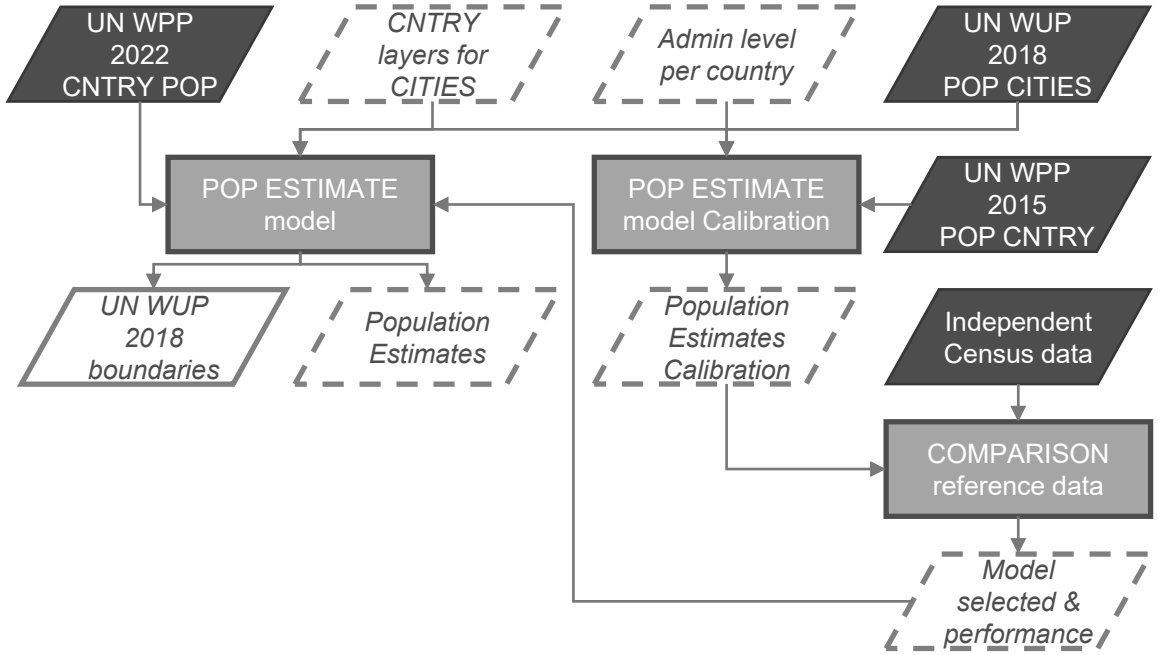
GHS-POP R2023A:
Multi-temporal population estimates (3)

CALIBRATION SET					
Belgium	-2.5%	Greece	-6.0%	Slovenia	-41.3%
Bulgaria	-33.1%	Croatia	-18.2%	Slovakia	-1.1%
Switzerland	30.4%	Ireland	0.7%	USA	-38.3%
Czechia	-61.1%	Iceland	-17.0%	Argentina	-14.5%
Germany	-58.9%	Italy	-8.5%	Nepal	-6.3%
Denmark	0.8%	Liechtenstein	-29.5%	Georgia_C	-35.0%
Estonia	-55.9%	Lithuania	-6.3%	New Zealand	-7.3%
Spain	-3.5%	Luxembourg	-59.3%	Afghanistan	-11.6%
Finland	8.7%	Martinique	-13.5%	Azerbaijan	-1.5%
France	-12.5%	Norway	-42.7%	Benin	0.0%
United Kingdom	-2.0%	Poland	-6.4%	Botswana	0.0%
French Guiana	-60.6%	Réunion	-19.9%	Guatemala	-4.6%
Guadeloupe	0.9%	Sweden	-49.9%	Myanmar	-16.6%
VALILDATION SET					
Austria	-70.7%	Latvia	-18.3%	Portugal	-0.7%
Cyprus	-9.7%	Malta	21.5%	Romania	-15.7%
Hungary	-36.2%	Netherlands	-38.0%	Kenya	-4.9%



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GHS-POP R2023A: Covariate selection

- Built-up covariate tested:
  - **Surface** (GHS-BUILT-S), **Volume** (GHS-BUILT-V)
    - TOT built-up layer as target (noNRES)
    - TOT built-up - full NRES layer (fullRES)
    - mixed TOT and NRES using weight (mixNRES)
    - mixed TOT and binarised NRES weight (binNRES)

	SOURCE ZONES		REF DATA	
Country	Aggregation	Units	Units	Pop 2020
JPN	10	5,016	501,600	126,146,099
BEL	7	25	32,140	11,485,814
FIN	32	385	352,885	5,424,562
KEN	admin4	2,713	7,125	53,771,300
AUS	SA1	61,819	368,286	25,418,422
COL	Municipio	1,122	551,028	46,925,773
TOTAL			1,813,064	269,171,970

	RMSE								%TAA							
	Surface				Volume				Surface				Volume			
Country	noNRES	fullRES	mixNRES	binNRES	noNRES	fullRES	mixNRES	binNRES	noNRES	fullRES	mixNRES	binNRES	noNRES	fullRES	mixNRES	binNRES
JPN	477.2	433.6	434.3	435.3	456.0	**381.3**	381.9	382.7	0.813	0.825	0.825	0.824	0.838	**0.859**	0.858	0.858
BEL	531.5	405.2	407.7	411.3	511.3	**311.9**	314.1	316.7	0.765	0.814	0.813	0.811	0.772	**0.852**	0.851	0.850
FIN	109.4	87.3	87.6	88.1	126.1	**79.9**	80.4	81.0	0.661	0.716	0.715	0.714	0.622	**0.723**	0.722	0.720
KEN	3847.8	3811.1	3811.8	3812.8	3780.1	**3725.0**	3725.5	3726.1	0.9095	**0.9103**	0.9102	0.9102	0.9087	0.9102	0.9102	0.9102
AUS	59.6	**57.975**	58.006	58.050	60.7	58.9	58.9	58.9	0.800	**0.8080**	0.8078	0.808	0.793	0.801	0.801	0.801
COL	317.9	270.4	271.3	272.6	316.0	**248.8**	249.4	250.2	0.468	0.473	0.473	0.473	0.453	0.460	0.460	**0.539**
TOTAL	***400.0***	***369.3***	***369.8***	***370.6***	***390.5***	***342.4***	***342.8***	***343.3***	***0.766***	***0.776***	***0.776***	***0.776***	***0.774***	***0.7909***	***0.7907***	***0.8847***

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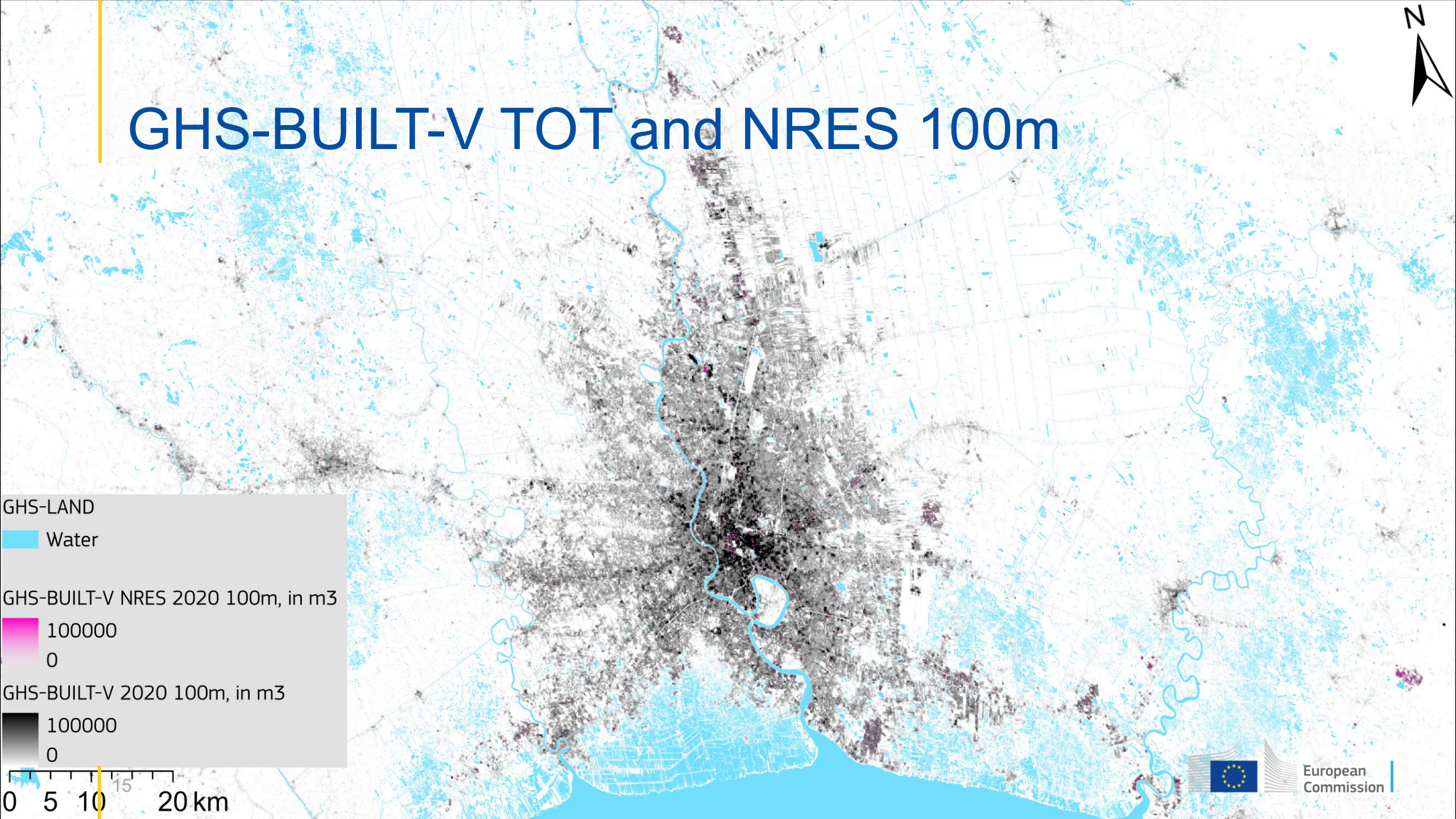
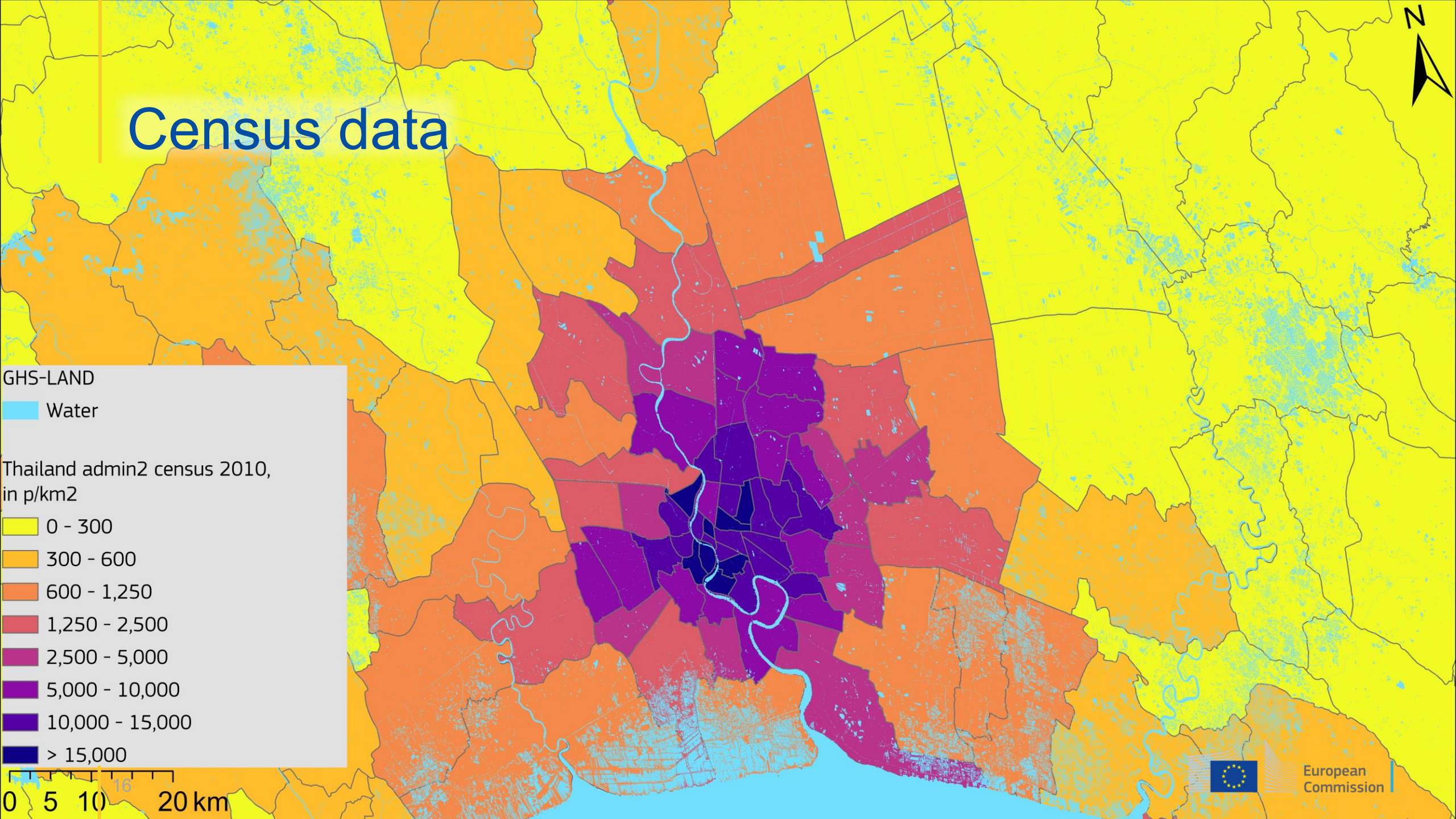
GHS-BUILT-V TOT and NRES 100m



Census data


N
GHS-LAND
Water
Thailand admin2 census 2010,
in p/km2
0 - 300
300 - 600
600 - 1,250
1,250 - 2,500
2,500 - 5,000
5,000 - 10,000
10,000 - 15,000
> 15,000
0 5 10 20 km
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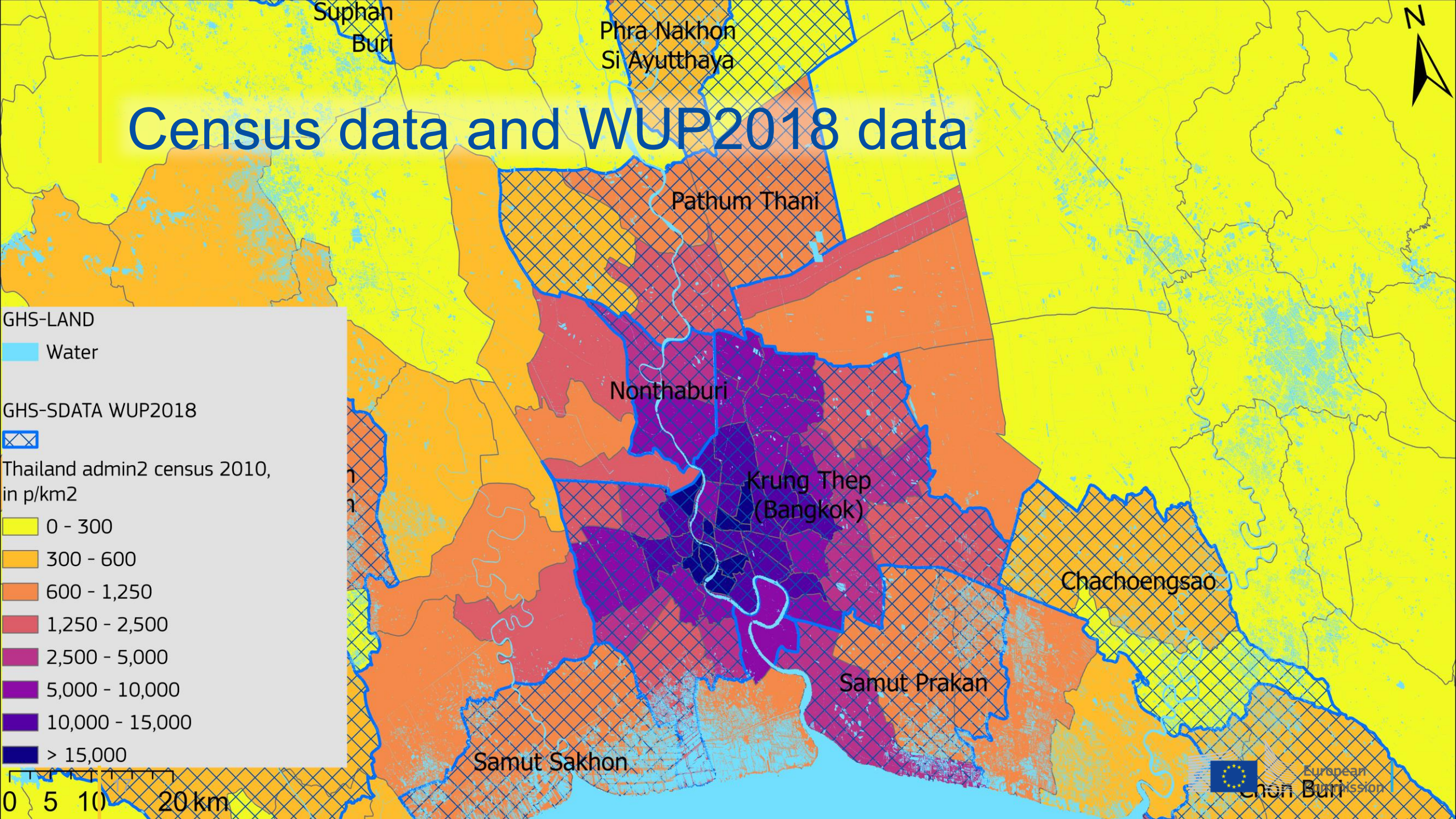
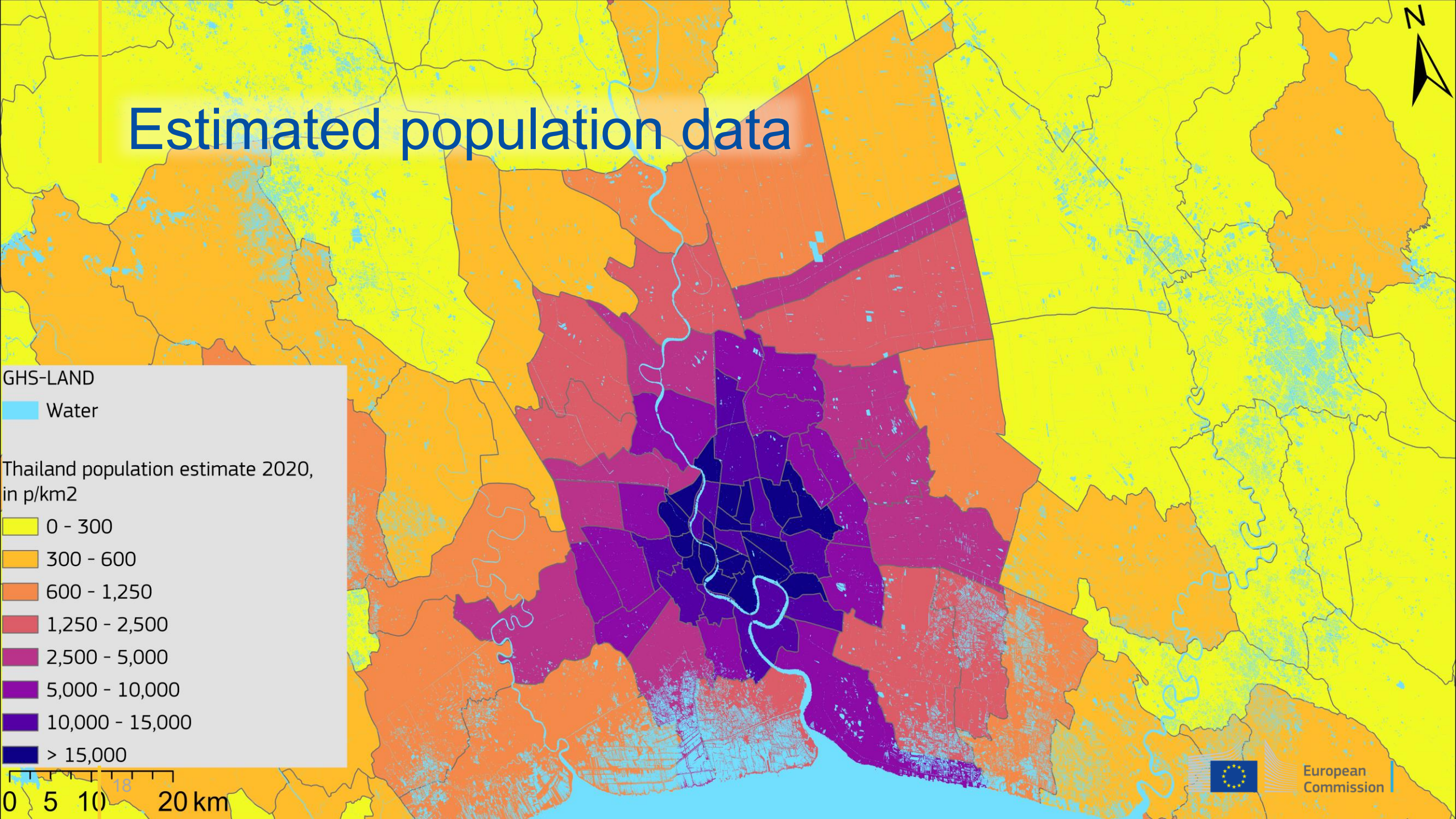
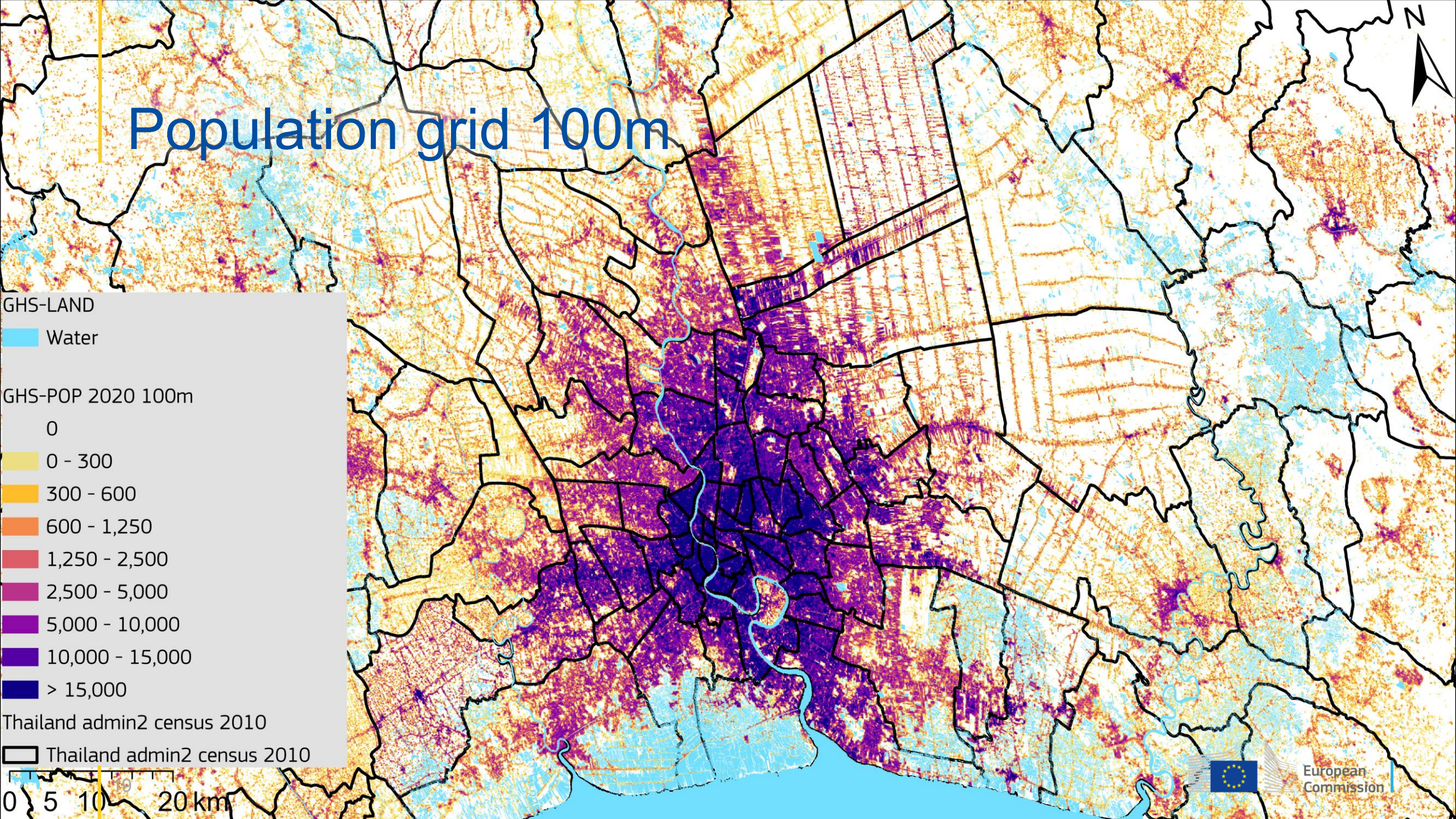
Census data and WUP2018 data



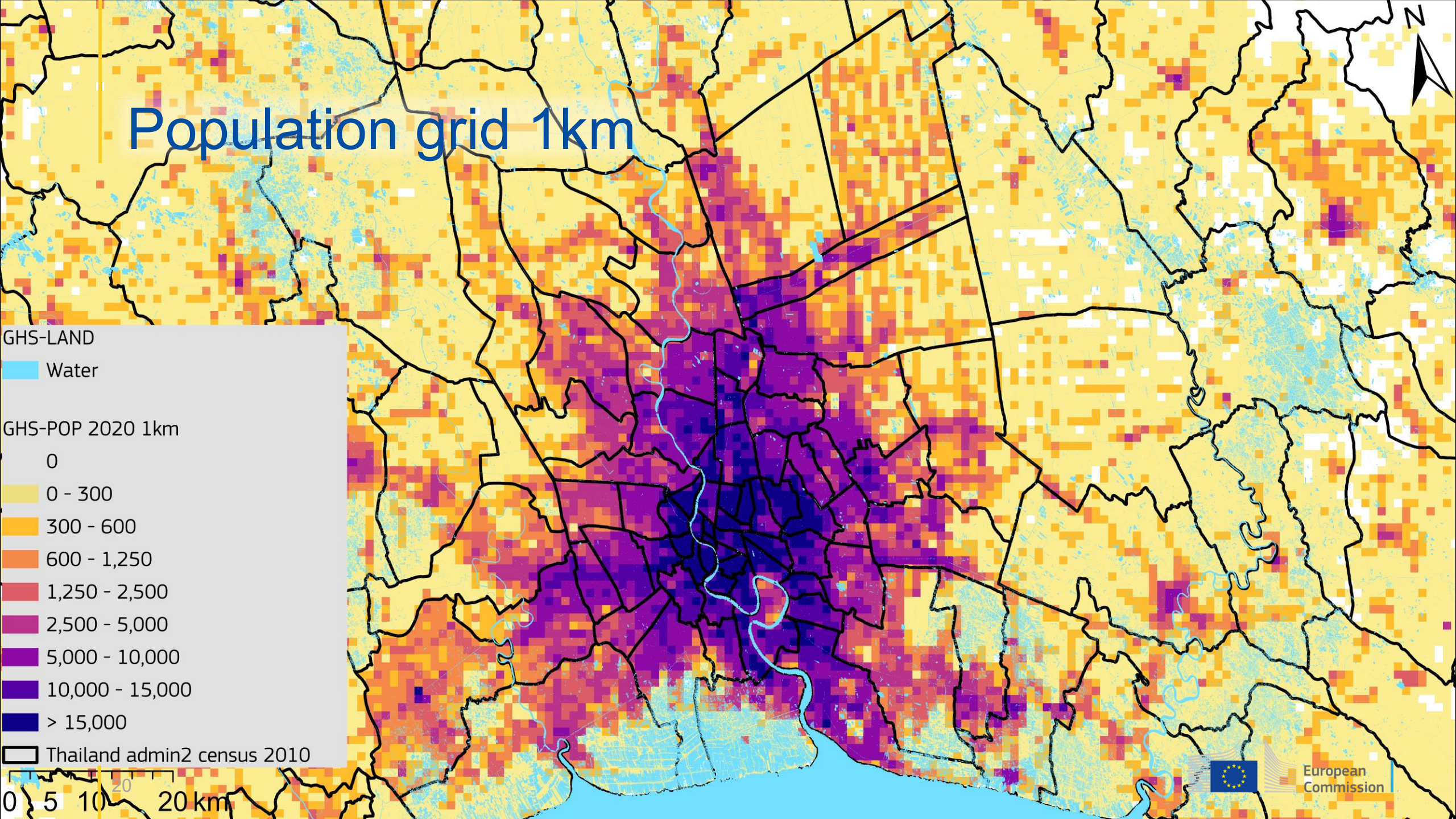
Estimated population data



Population grid 100m

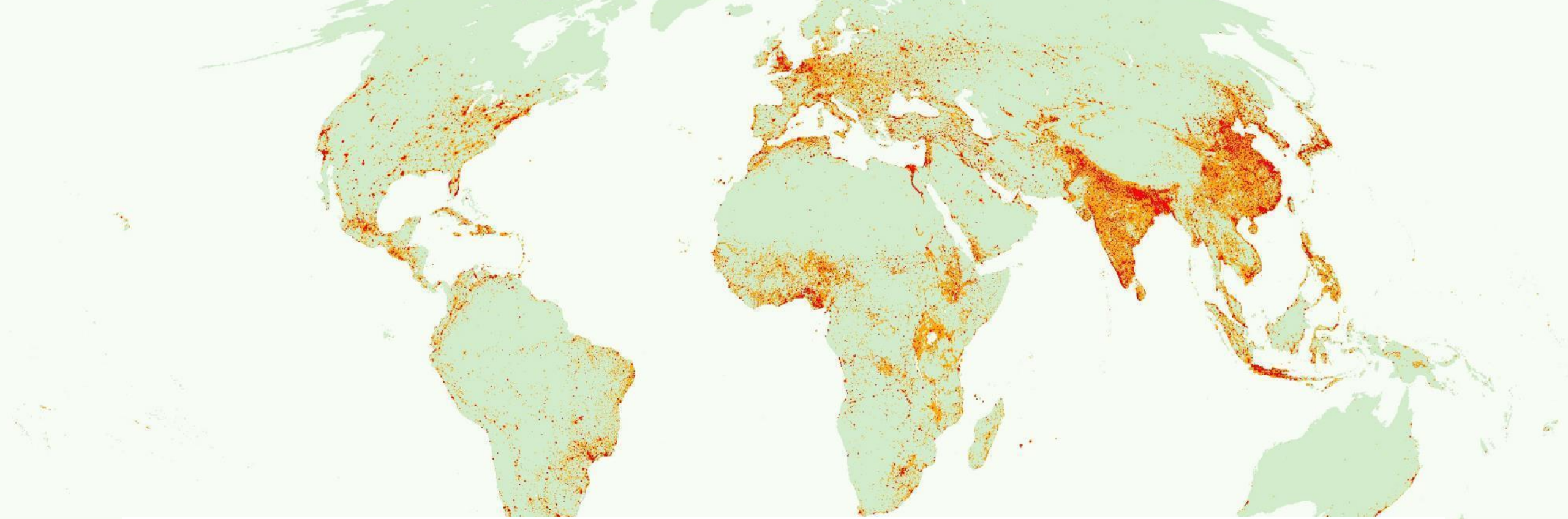


Population grid 1km



The Degree of Urbanisation

What is
Why
How

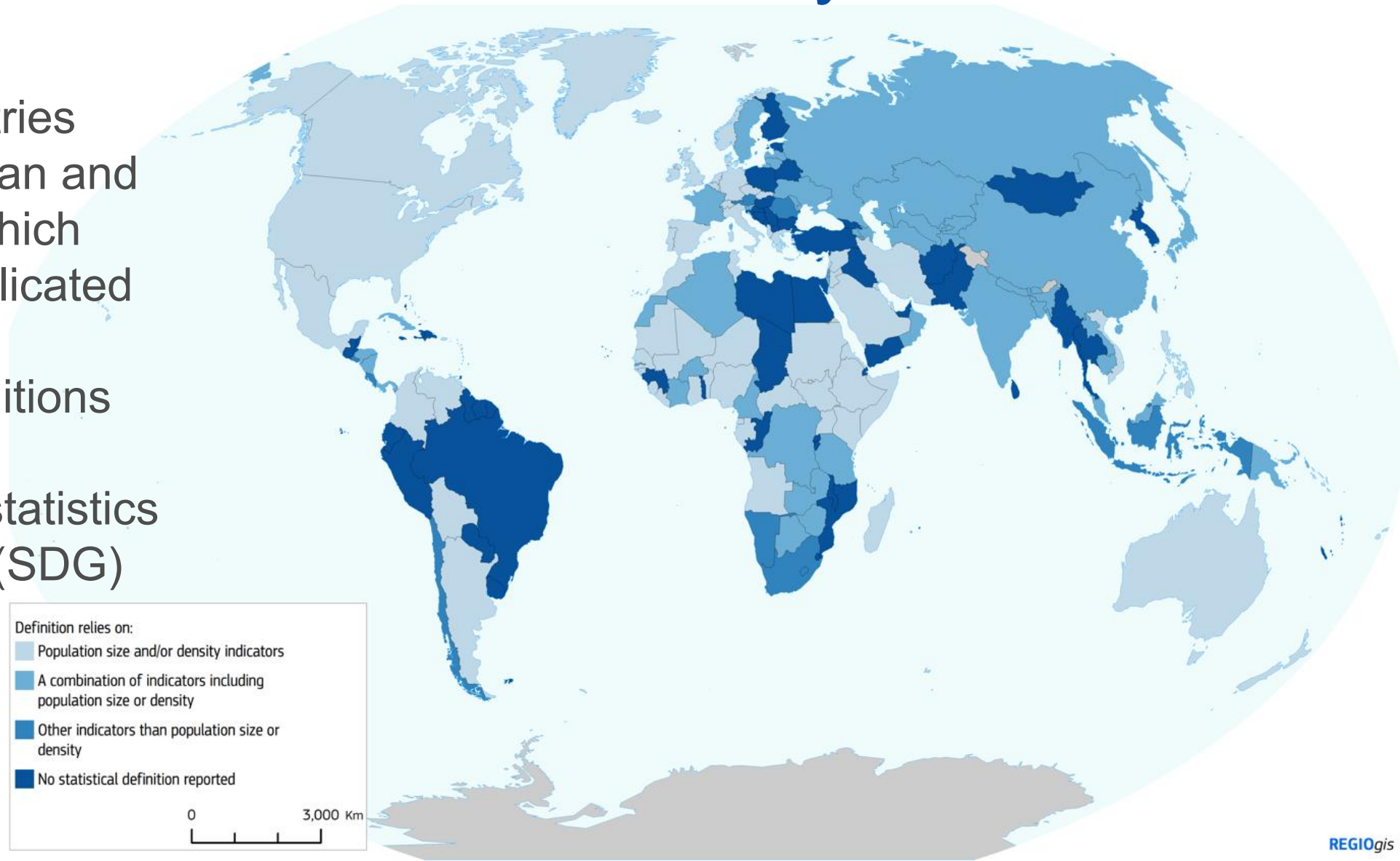


The Degree of Urbanisation: What is

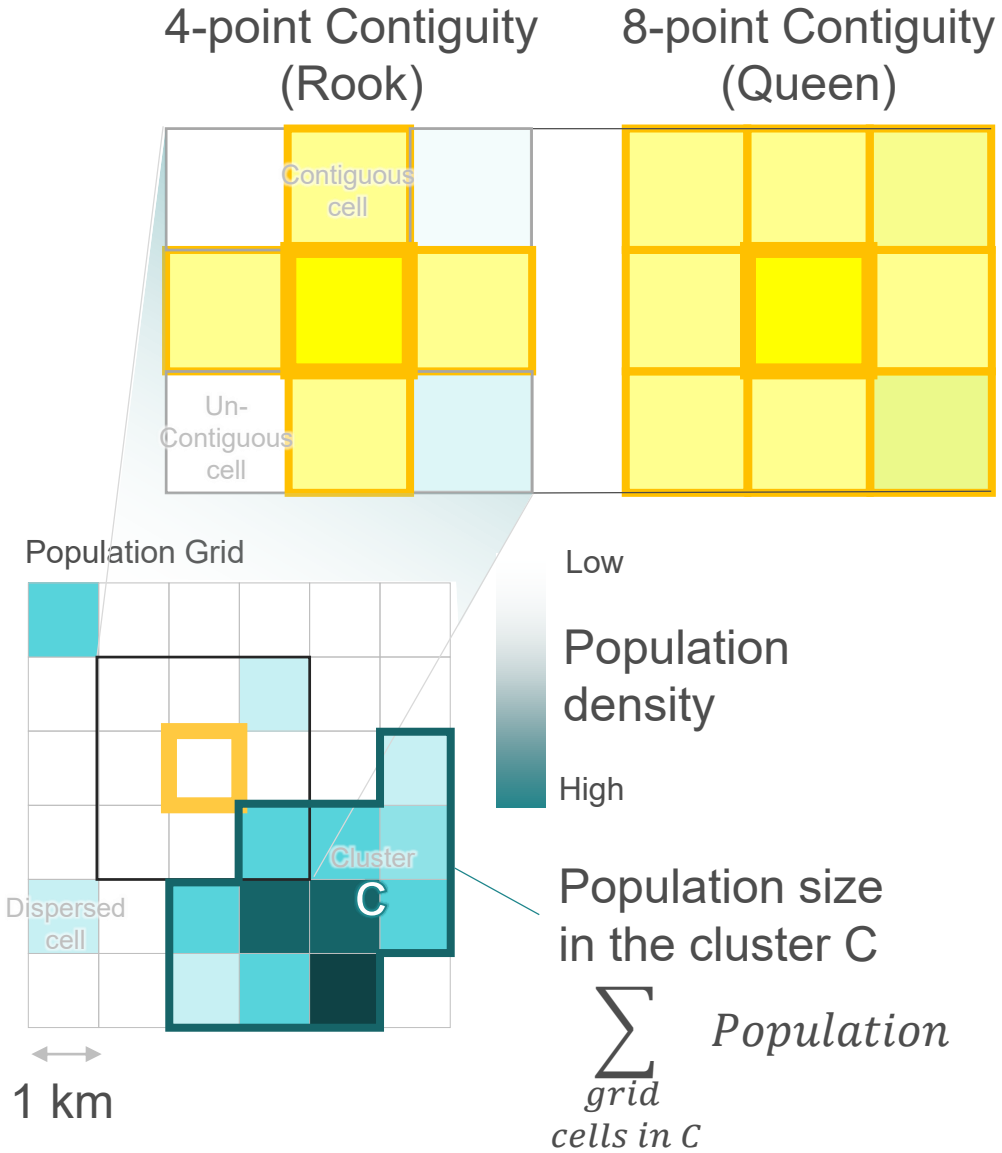
- The Degree of Urbanisation (DEGURBA) is a population based methodology recommended by UN to classify the urban/rural continuum
  - Harmonised people-centric definition for international statistical comparison (SDG)
  - Based on 1km population grid in equal area projection
  - Classification grid (Stage I) and classification of territorial units (Stage II)

The Degree of Urbanisation: Why

- Half the countries designate urban and rural areas, which cannot be replicated
- Different definitions hamper the possibility of statistics comparisons (SDG)



The Degree of Urbanisation: How (Stage I, 1)



- Each grid cell is classified according to a set of rules applied on a 1km equal era population grid:
- **Population density** of each cell
- **Contiguity & distance** between cells to form clusters of cells
- **Population size** of the clusters

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The Degree of Urbanisation: How (Stage I, 2)

1st Level

Urban areas

- Urban centres
- Urban clusters

- Rural grid cells

2nd Level

- Dense Urban clusters
- Semi-dense Urban clusters
- Suburban, peri-urban grid cells

- Rural clusters
- Low density rural grid cells
- Very Low density rural grid cells

- See the online manual for details on the classes

Icons credits: City by Muhajir ila Robbi from the Noun Project, Town by Alice Design from the Noun Project, Farm by Andi Nur Abdillah from the Noun Project

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The Degree of Urbanisation: How (Stage II, 1)

- Territorial units are classified based on
  - Settlement grid classification
  - Population grid
- Makes possible to **disaggregate existing local statistics in the 3 or 7 classes**

Cities	***≥ 50% pop. in urban centres***
Towns and suburbs	***≥ 50% pop. in urban clusters and not classified as city***
Rural area	***> 50% pop. in rural grid cells***

The Degree of Urbanisation: How (Stage II, 2)

1st Level	2nd Level
Urban areas	
cities	
towns and semi-dense areas	towns (dense / semi-dense)
	suburban, peri-urban areas
rural areas	villages
	dispersed rural areas
	mostly uninhabited areas

- See the online manual for details on the classes

Icons credits: City by Muhajir ila Robbi from the Noun Project, Town by Alice Design from the Noun Project, Farm by Andi Nur Abdillah from the Noun Project

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The porting of the Degree of Urbanisation into the GHSL framework: GHS-SMOD and GHS-DUC R2023A

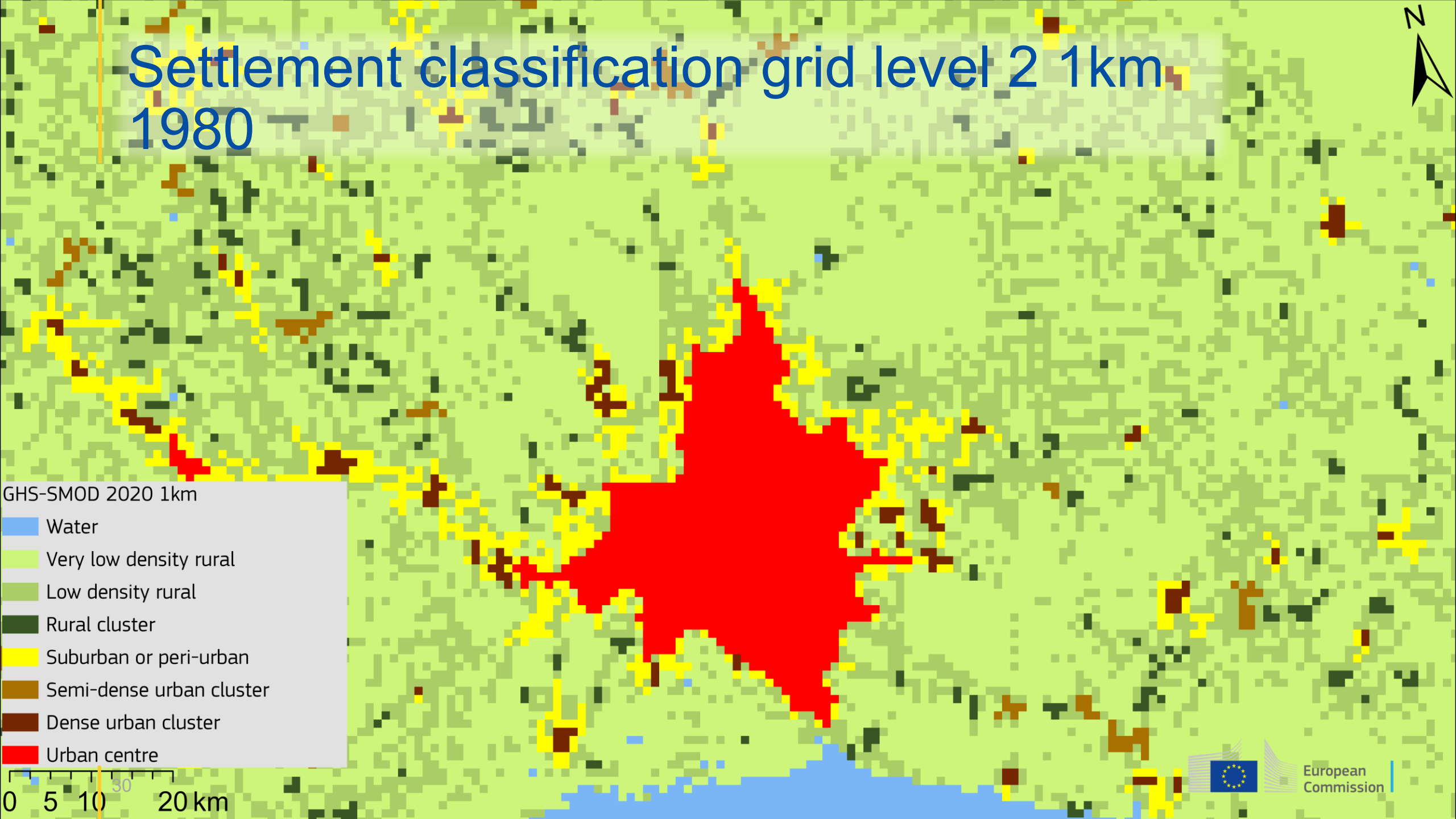
GHS-SMOD and GHS-DUC R2023A

- The GHS-SMOD is the settlement classification grid produced by applying the Degree of Urbanisation Stage I to each epoch (1975-2030, 5yrs interval) of the GHS-POP 1-km

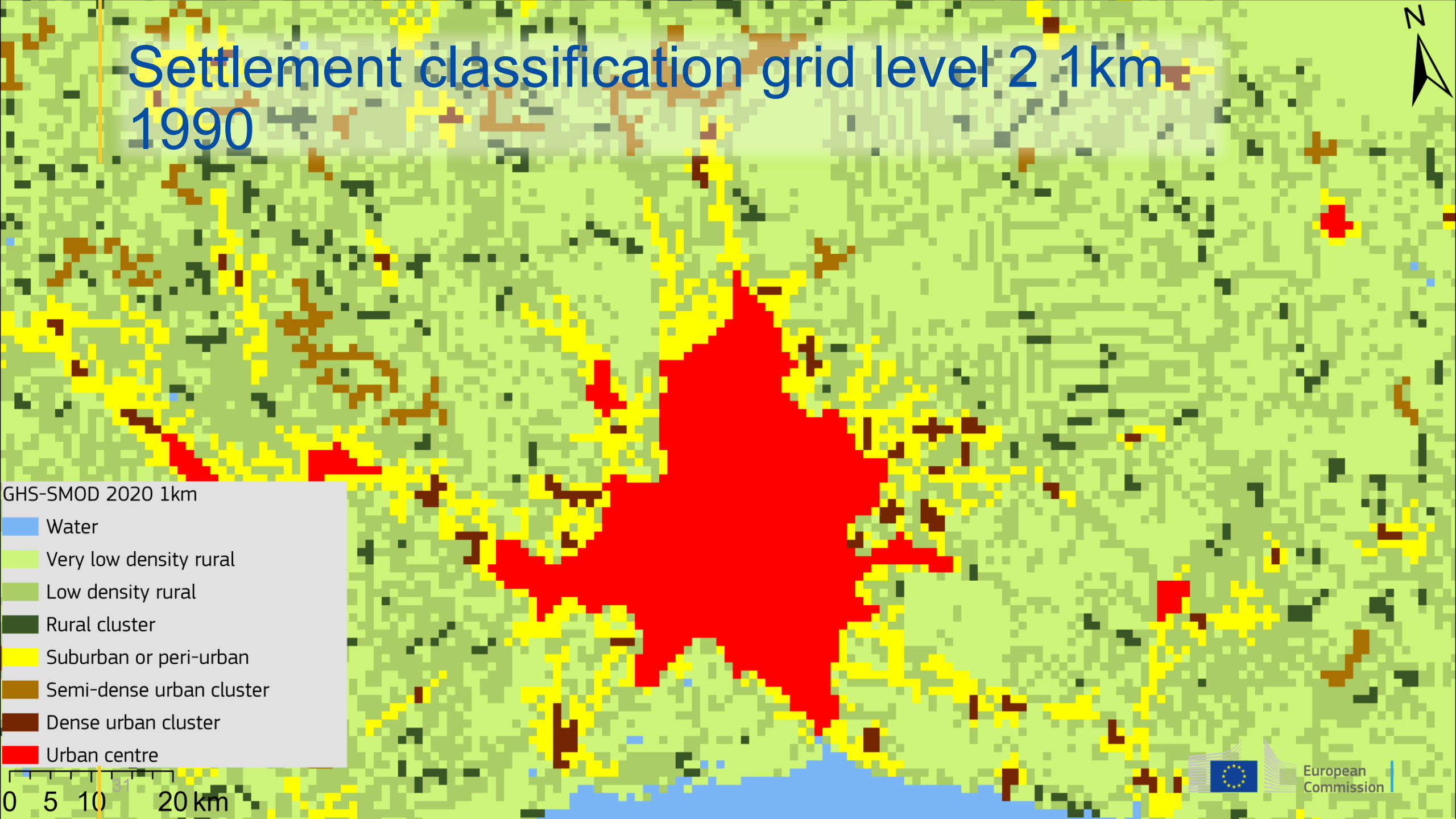
- The GHS-DUC is the Global Administrative boundaries layer (GADM, www.gadm.org) classified according to the Degree of Urbanisation Stage II:
  - GHS-SMOD as settlement classification grid
  - GHS-POP 100m as population counts

  - This is only a exemplificative exercise to show how the Degree of Urbanisation Stage II can be applied; there are no statistics associated to the GADM geometry to be disaggregated and produce indicators by Degree of Urbanisation and GADM geometry is quite coarse for some countries

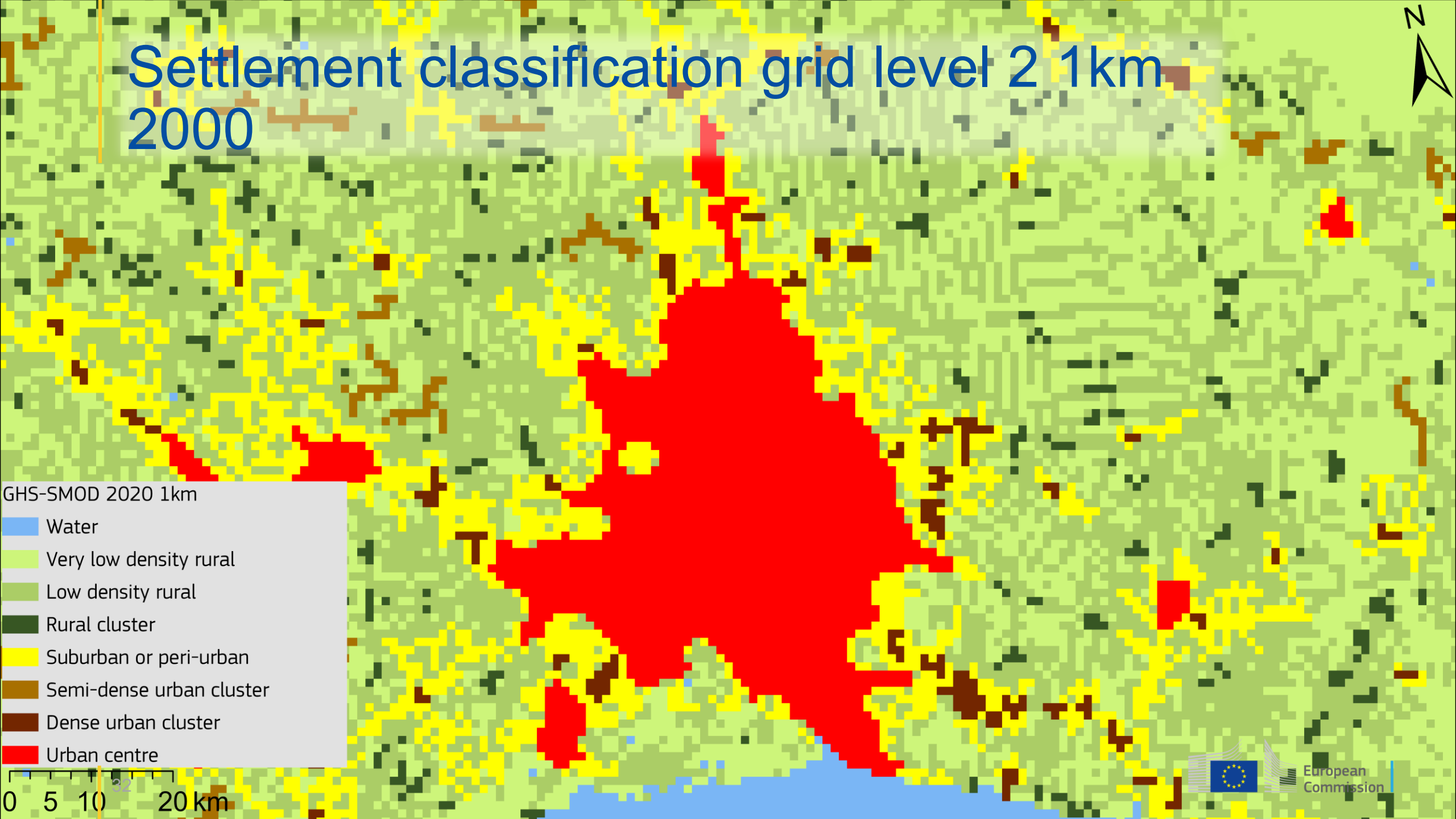
Settlement classification grid level 2 1km 1980



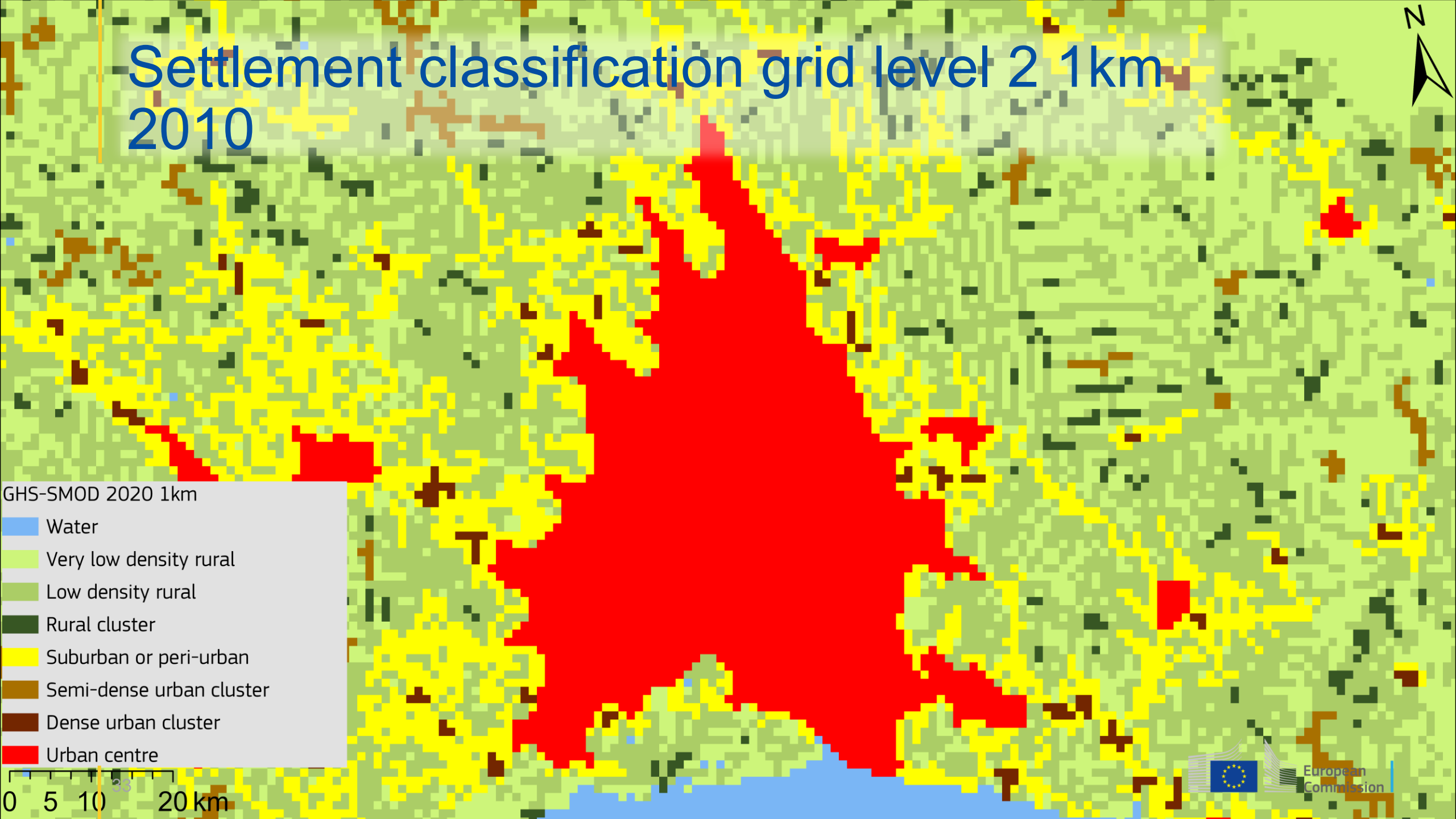
Settlement classification grid level 2 1km 1990



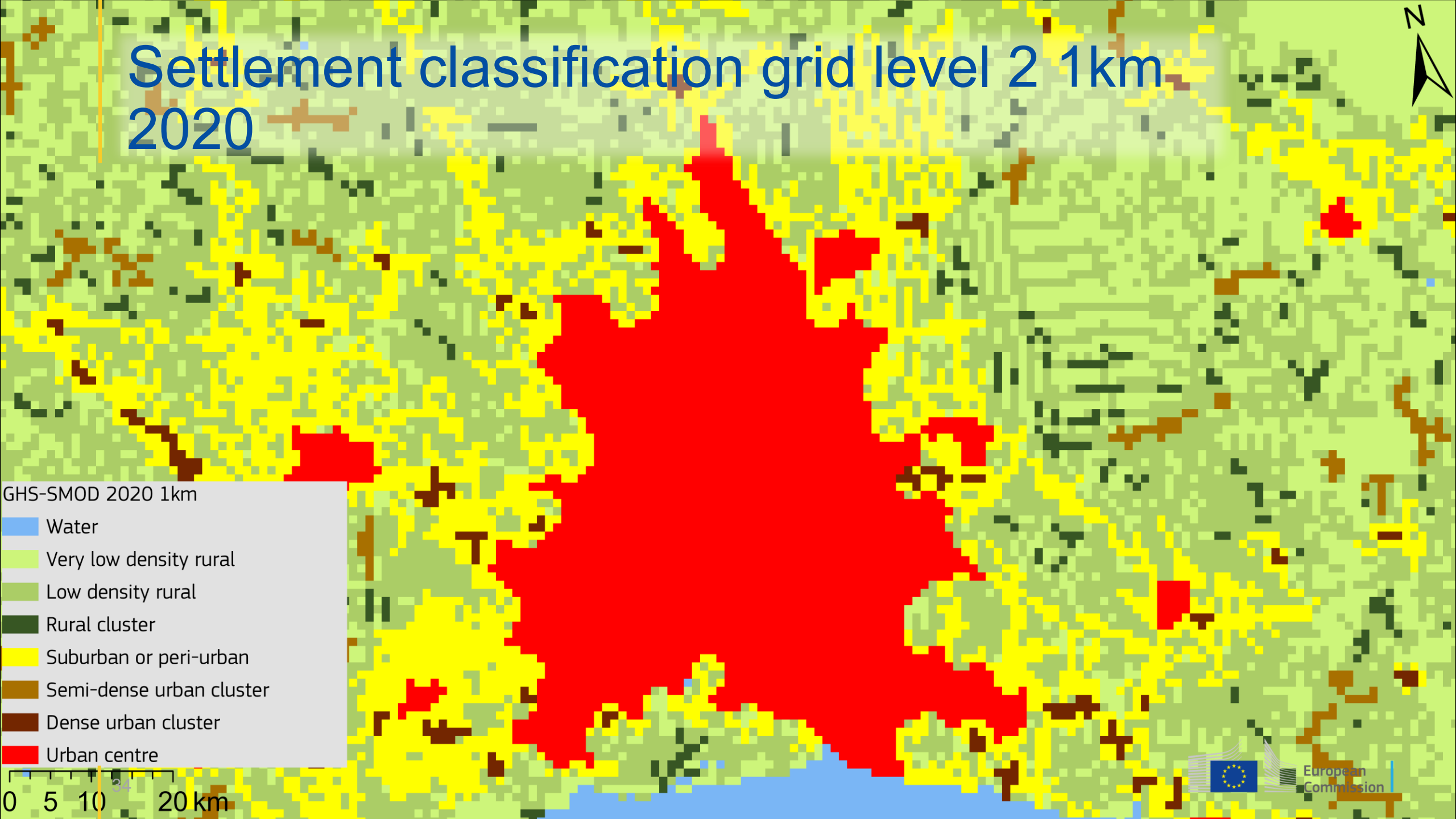
Settlement classification grid level 2 1km 2000



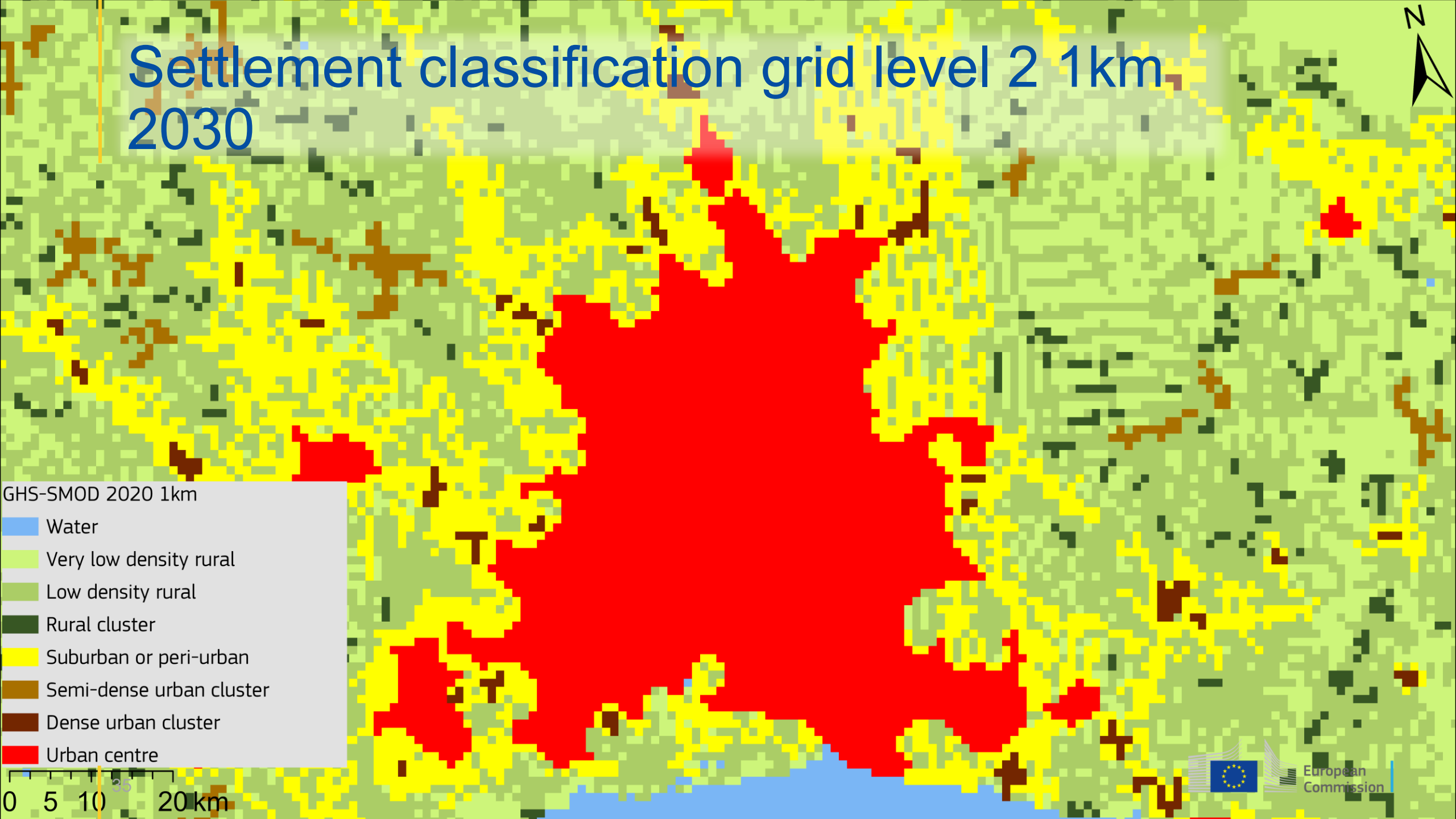
Settlement classification grid level 2 1km 2010



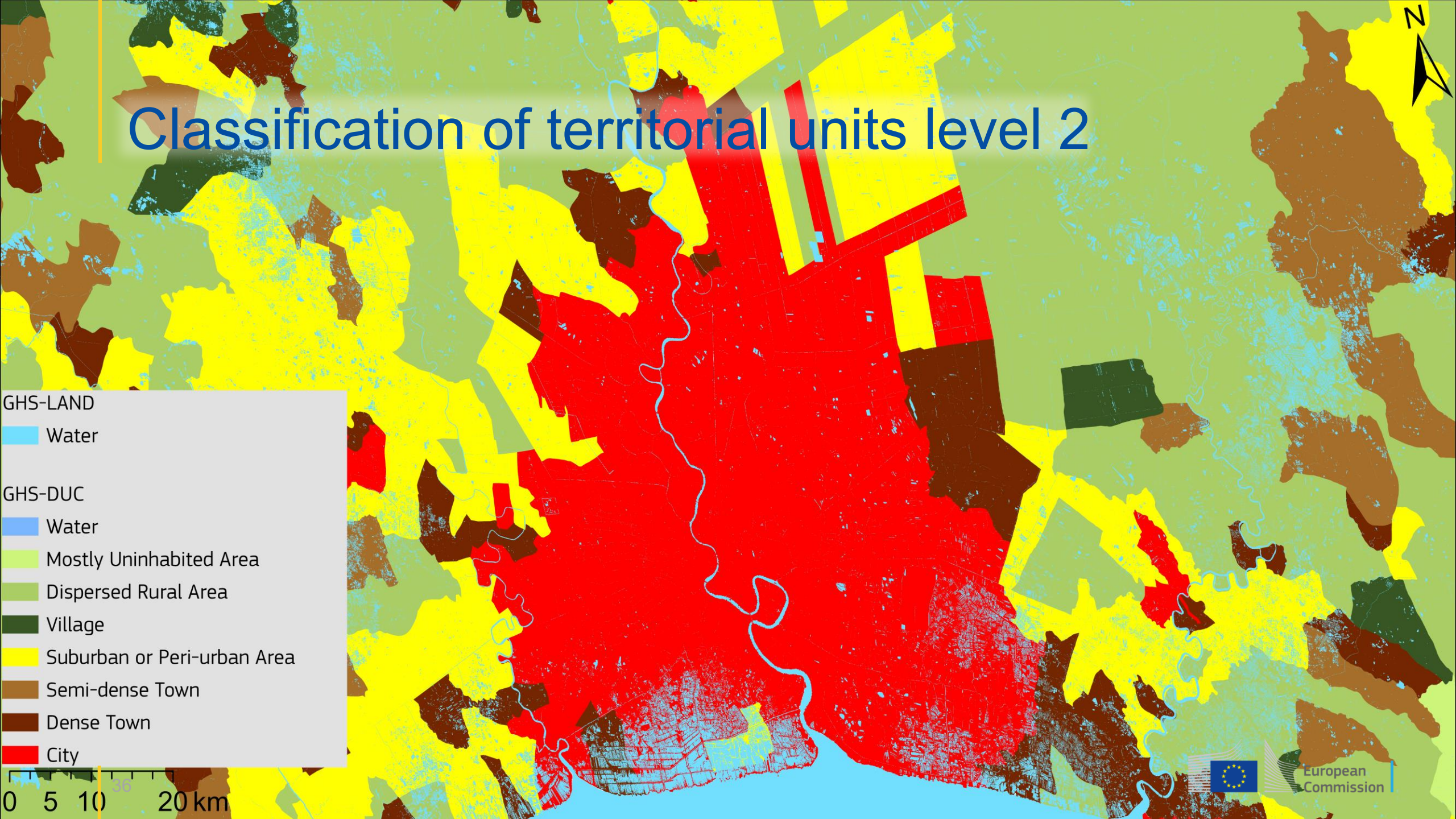
Settlement classification grid level 2 1km 2020



Settlement classification grid level 2 1km 2030

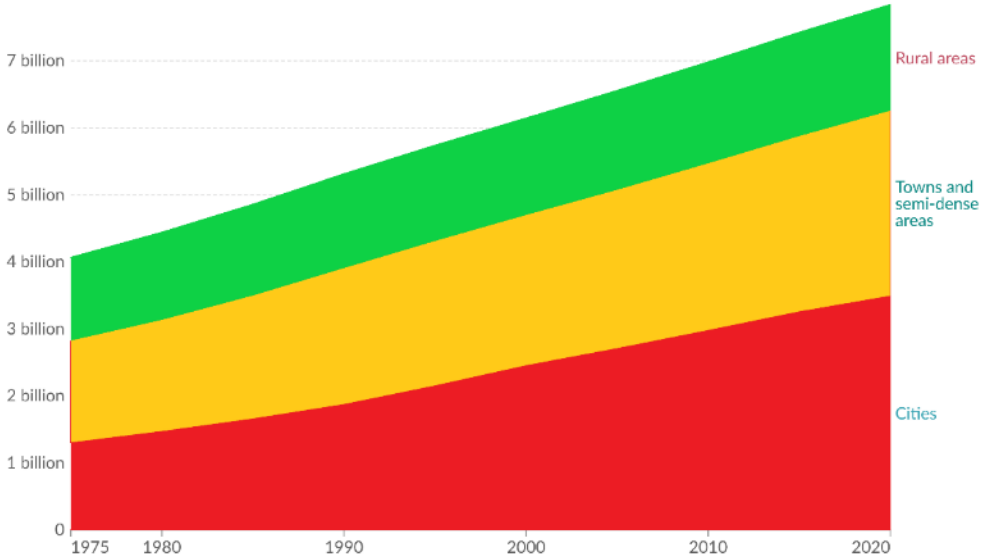


Classification of territorial units level 2

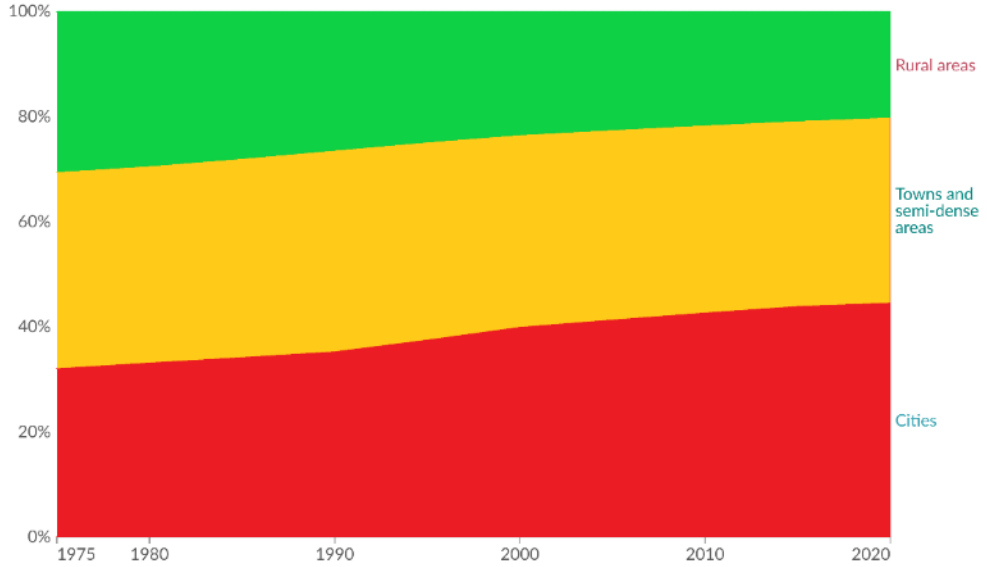


GHS-SMOD R2023A: Global Results

Between 1975 and 2020:
urban centre pop almost x3
urban cluster pop almost x2



The global urban share:
69% (32%+37%) in 1975
80% (45%+35%) in 2020



Here more charts derived from these data, chart source OurWorldInData.org

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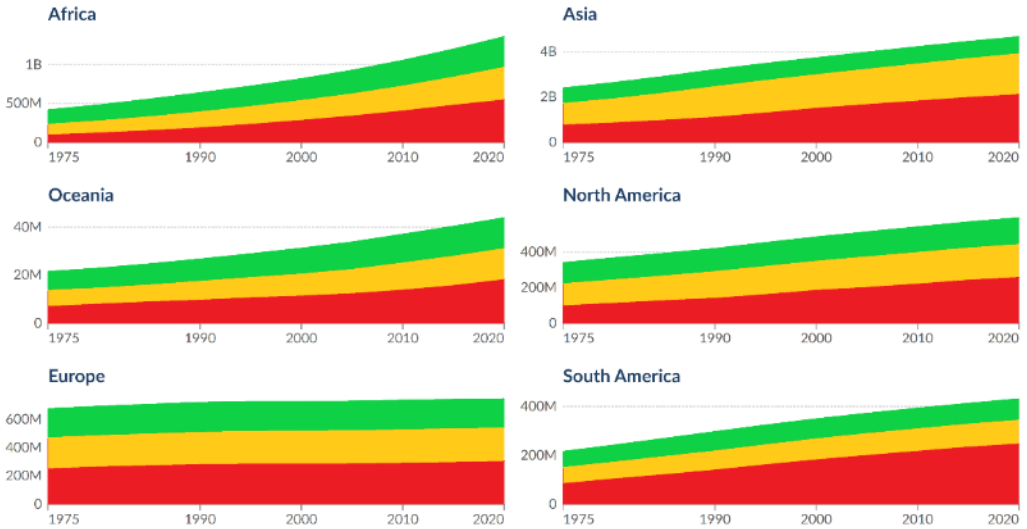
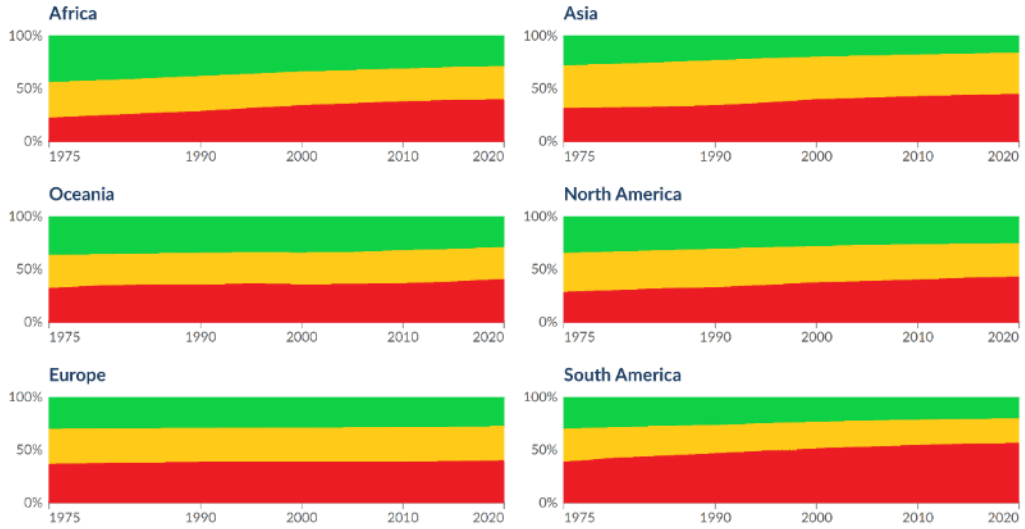
GHS-SMOD R2023A: Regional Results

Africa has the largest increment in urban centre: from 96M to 550M (x5.7)



South America has the largest share of urban centre population: 57%



[Here more charts derived from these data](), chart source OurWorldInData.org

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Thank you for your attention

Global Human Settlement Layer
https://human-settlement.emergency.copernicus.eu/
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