

The European Commission's science and knowledge service

Joint Research Centre



Indicators, datasets and mapping developed at Global level by the Joint Research Centre: opportunities, constraints, challenges

Marcello Schiavina & GHSL team

UNDERSTANDING LAND TAKE Indicators, datasets, mapping. Bologna, 7/11/2019

JRC Managing our wealth of knowledge



Knowledge Centre
for Food Fraud
and Quality



Knowledge Centre
for Territorial
Policies



Knowledge Centre
on Migration and
Demography



Knowledge Centre
for Disaster Risk
Management



Knowledge Centre
for Bioeconomy



Knowledge Centre
for Global Food
Security

The European Commission's science and knowledge service

Joint Research Centre

 EU Science Hub: ec.europa.eu/jrc  @EU_ScienceHub  Joint Research Centre

 EU Science Hub - Joint Research Centre  EU Science Hub

The Global Human Settlement Layer

open input, open method,
open output

Full repeatability

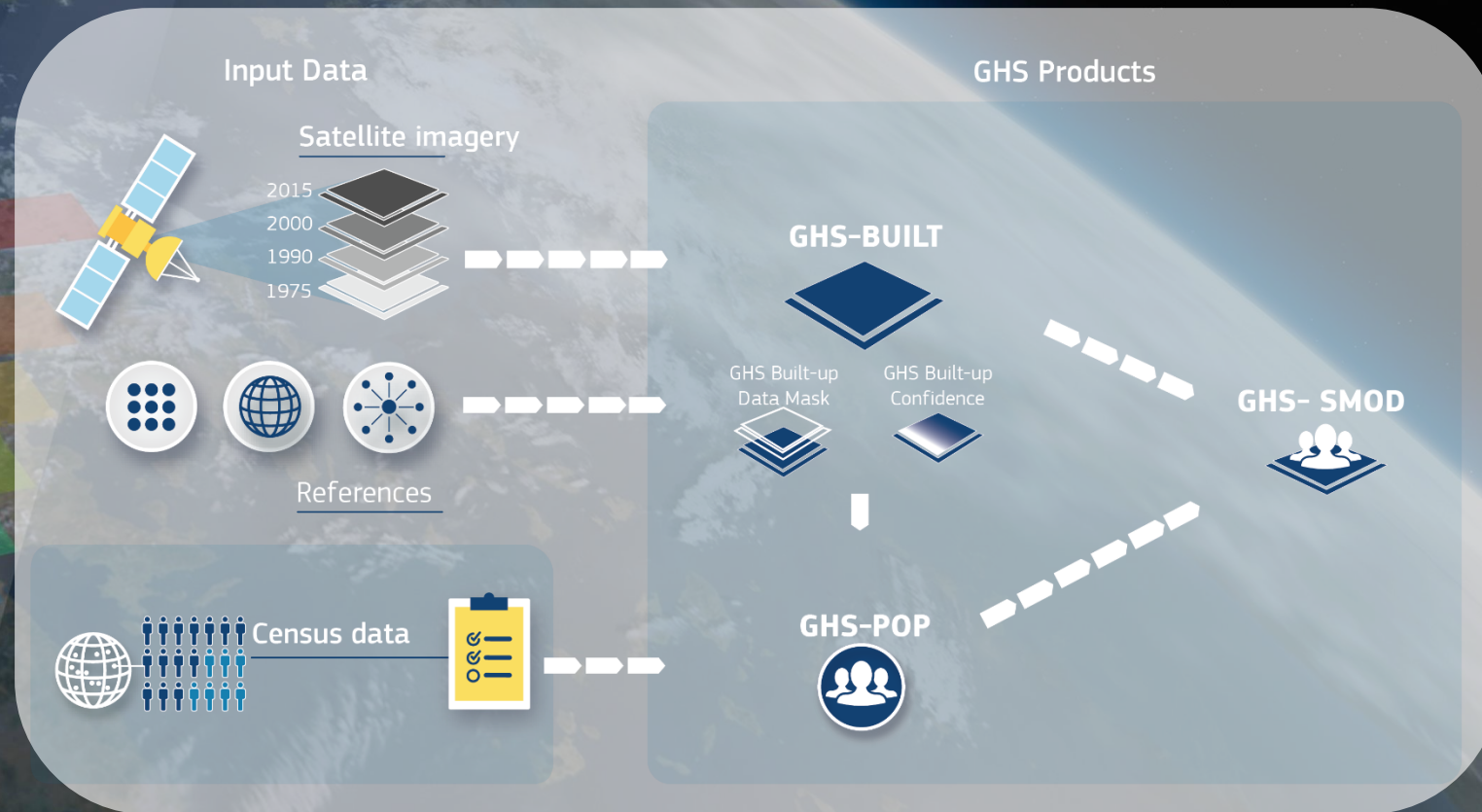
Multi-temporal and spatial
harmonization of information

Evidence-based output
analytics

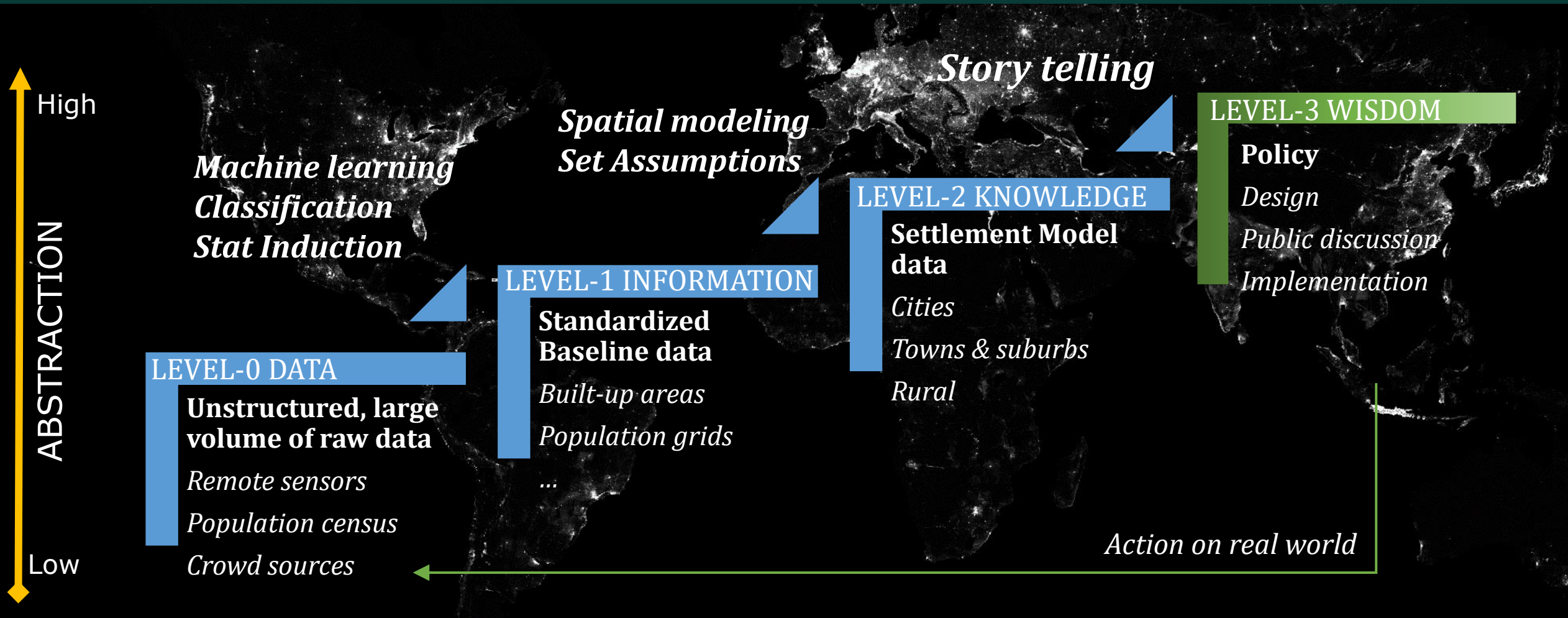
Real-world (big) data scenario

Produce new evidence for decision making:

- 2030 Agenda for Sustainable Development (SDGs)
- Sendai Framework for Disaster Risk Reduction
- New Urban Agenda

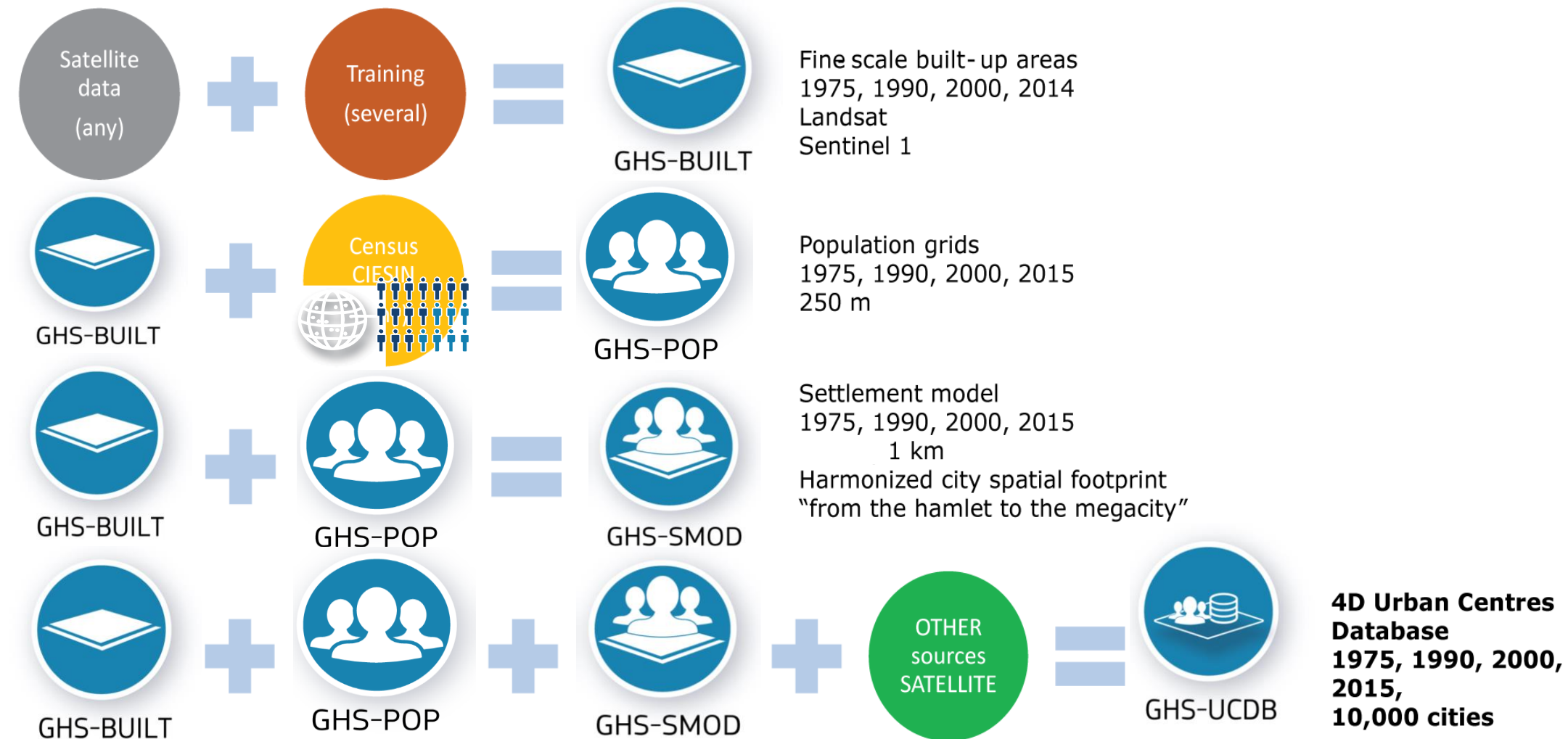


Hierarchical data processing paradigm



GHSL: a data family

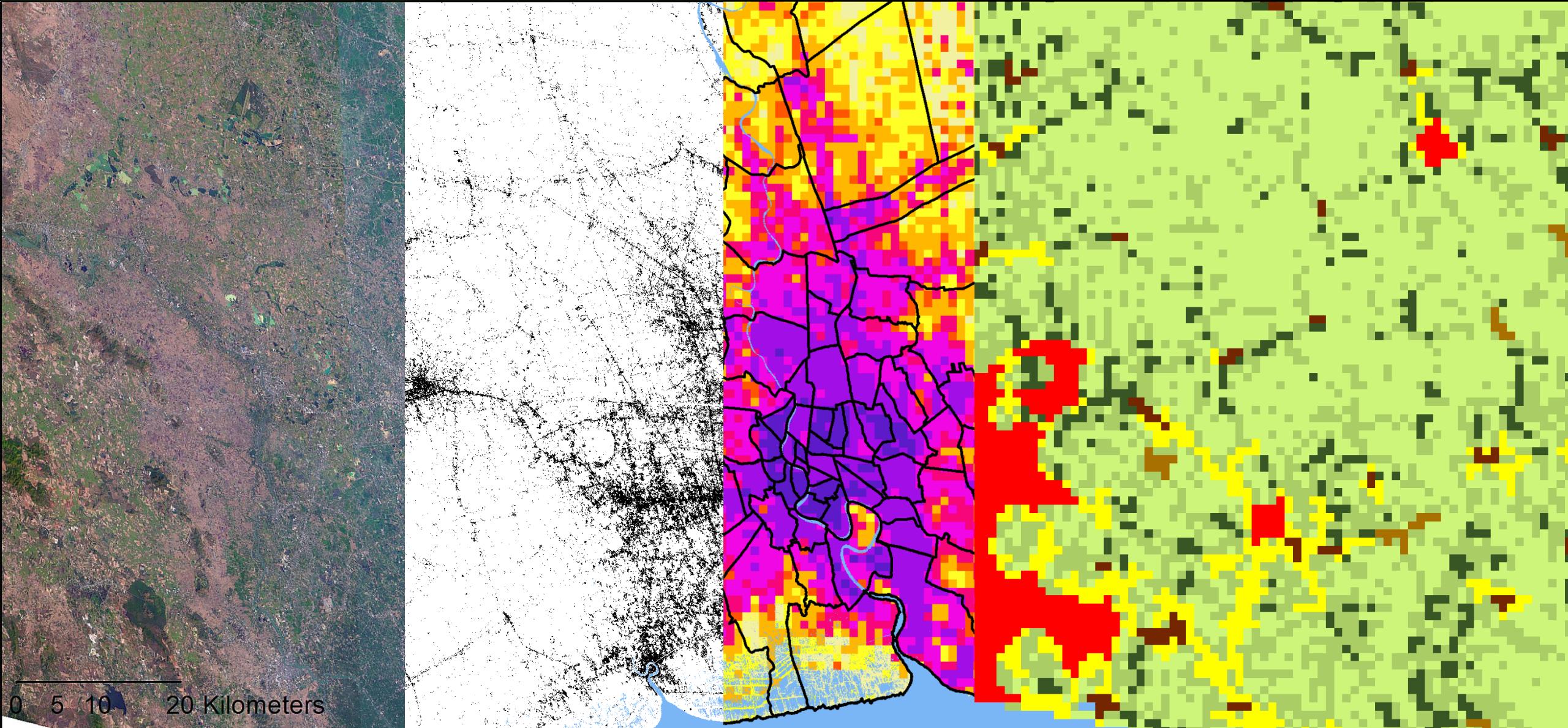
GHSL Baseline data anatomy



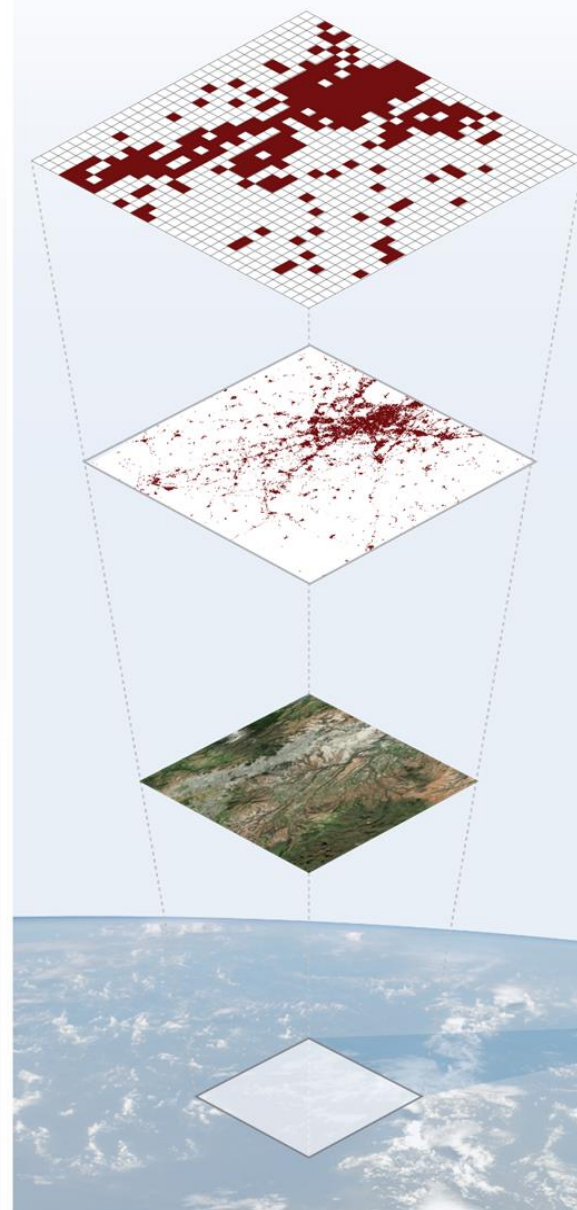
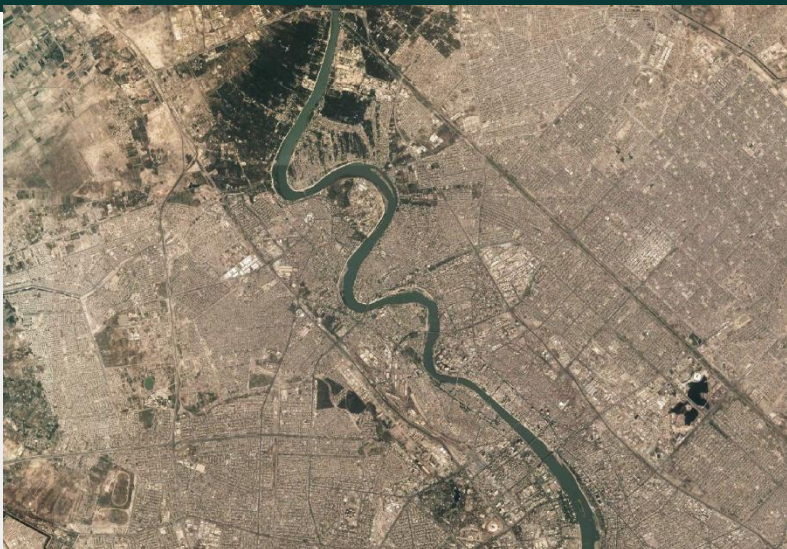
Images

| Built-up areas | Population |

Settlement
model



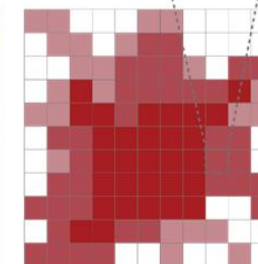
From Earth's Surface... to Pixels... to Built-up areas



Built-up area



100%
0%



Built-up extraction

Built-up extraction

GHLS
METHOD



Satellite imagery

Satellite imagery

IMAGE
ACQUISITION

Earth Surface

Earth surface



GHS-BUILT



GHS-BUILT

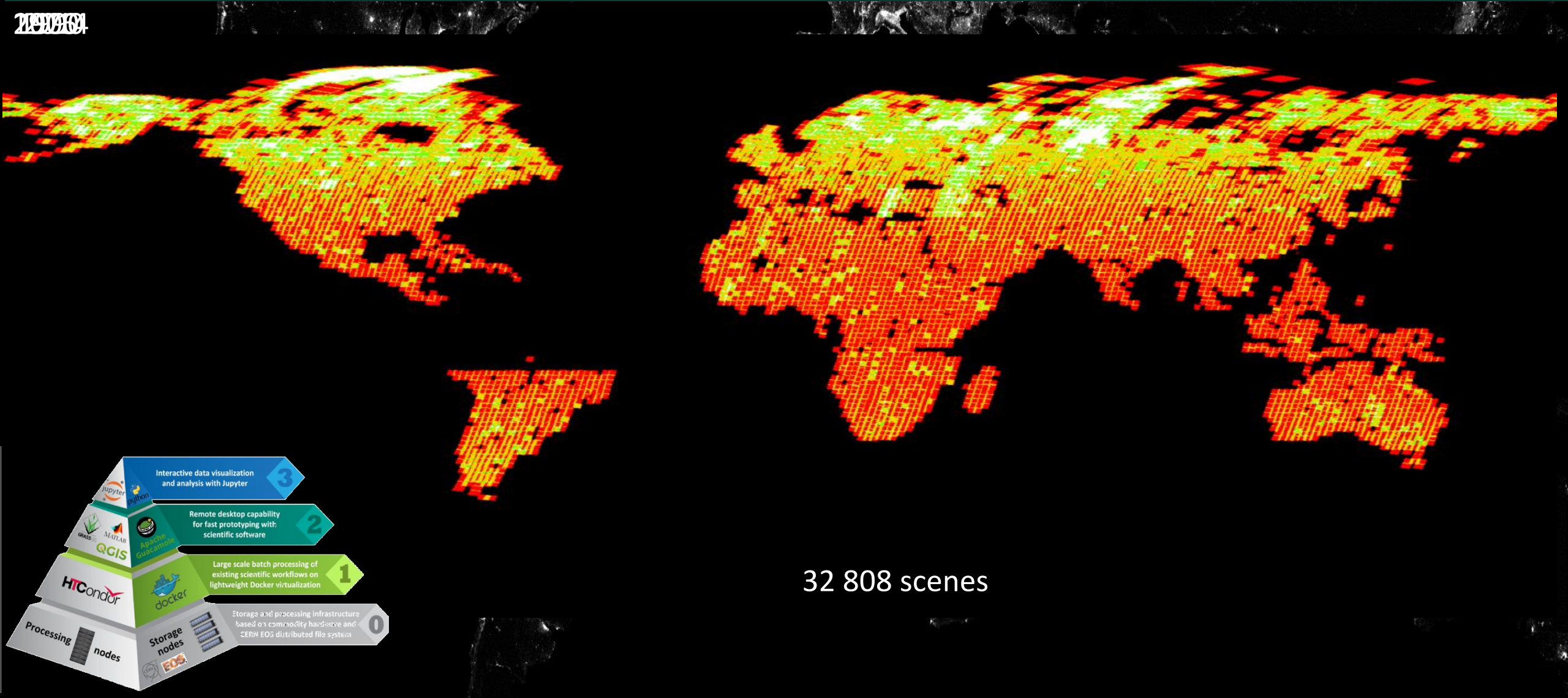


What we detect: "built-up area" = all spatial units (30x30m Landsat, 10x10m Sentinel) where a roofed building or part of a building can be recognized

Global coverages of Landsat data



GHS-BUILT

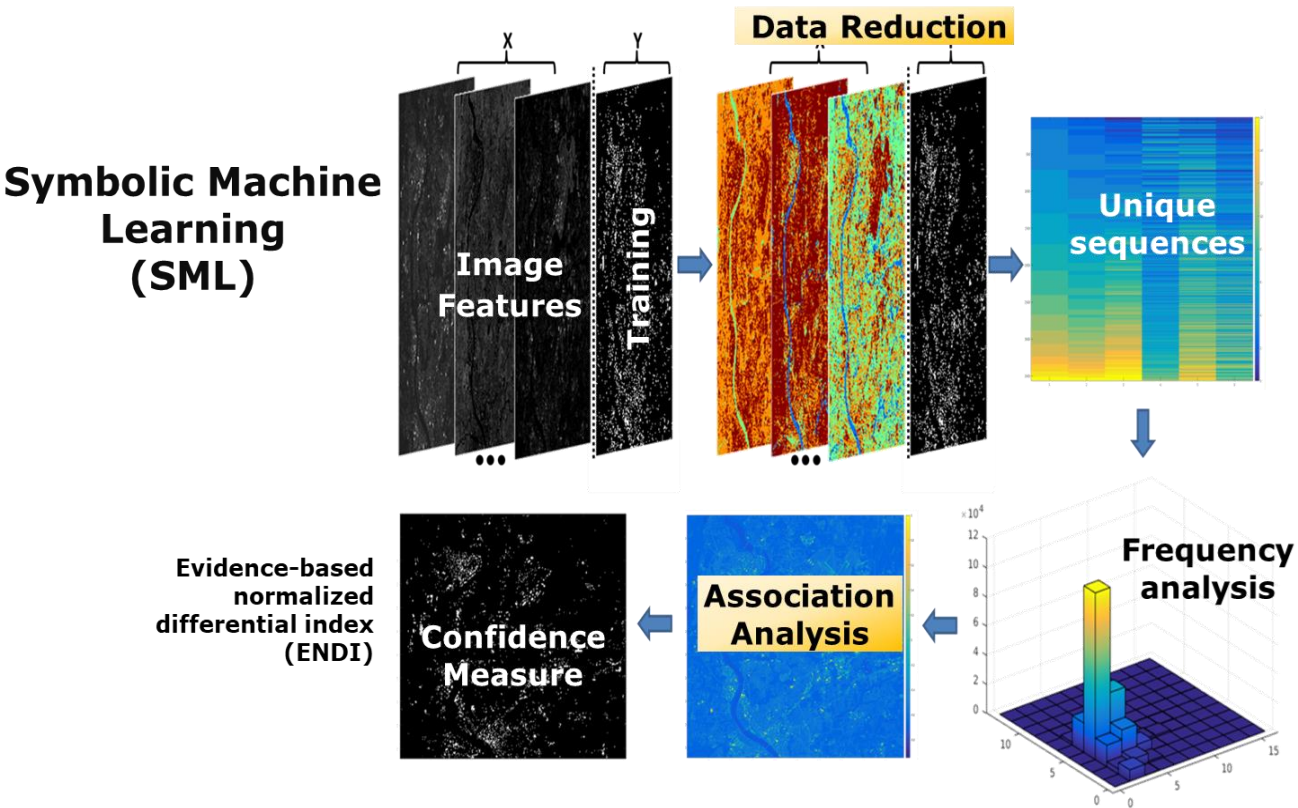


32 808 scenes



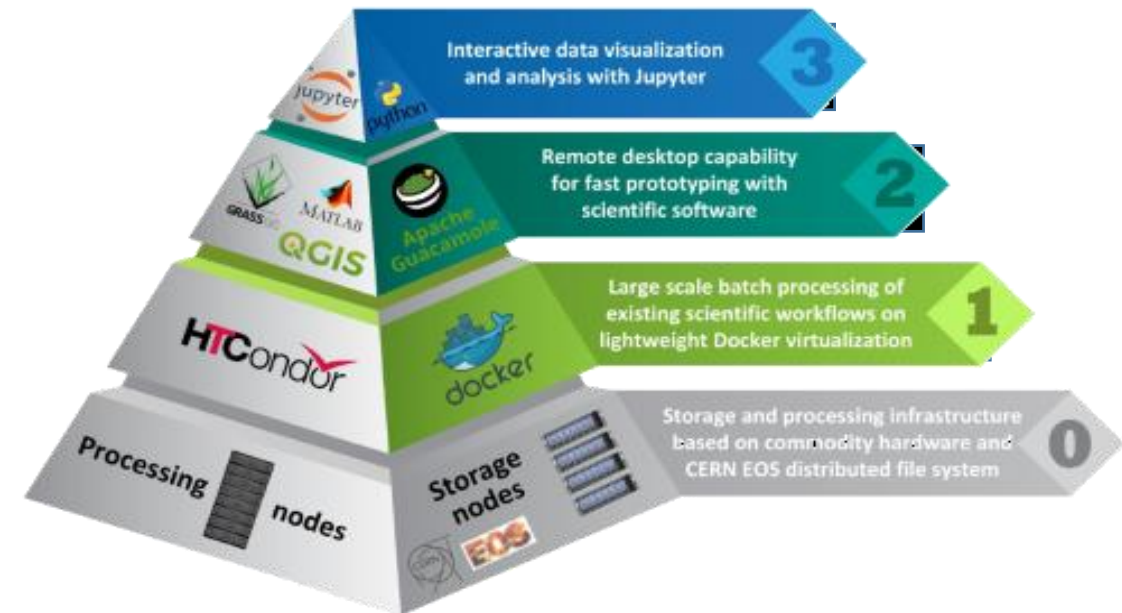
Machine Learning tools

JRC Symbolic Machine Learning



Big Data Infrastructure

JRC Big Data Platform JEODPP





Journal

Big Earth Data >

Volume 3, 2019 - Issue 2

This Journal ▾



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Data Articles



Open access

Automated global delineation of human settlements from 40 years of Landsat satellite data archives

Christina Corbane  , Martino Pesaresi , Thomas Kemper , Panagiotis Politis, Aneta J. Florczyk ,
Vasileios Syrris , ...show all

Pages 140-169 | Received 08 Mar 2019, Accepted 21 May 2019, Published online: 28 Jun 2019

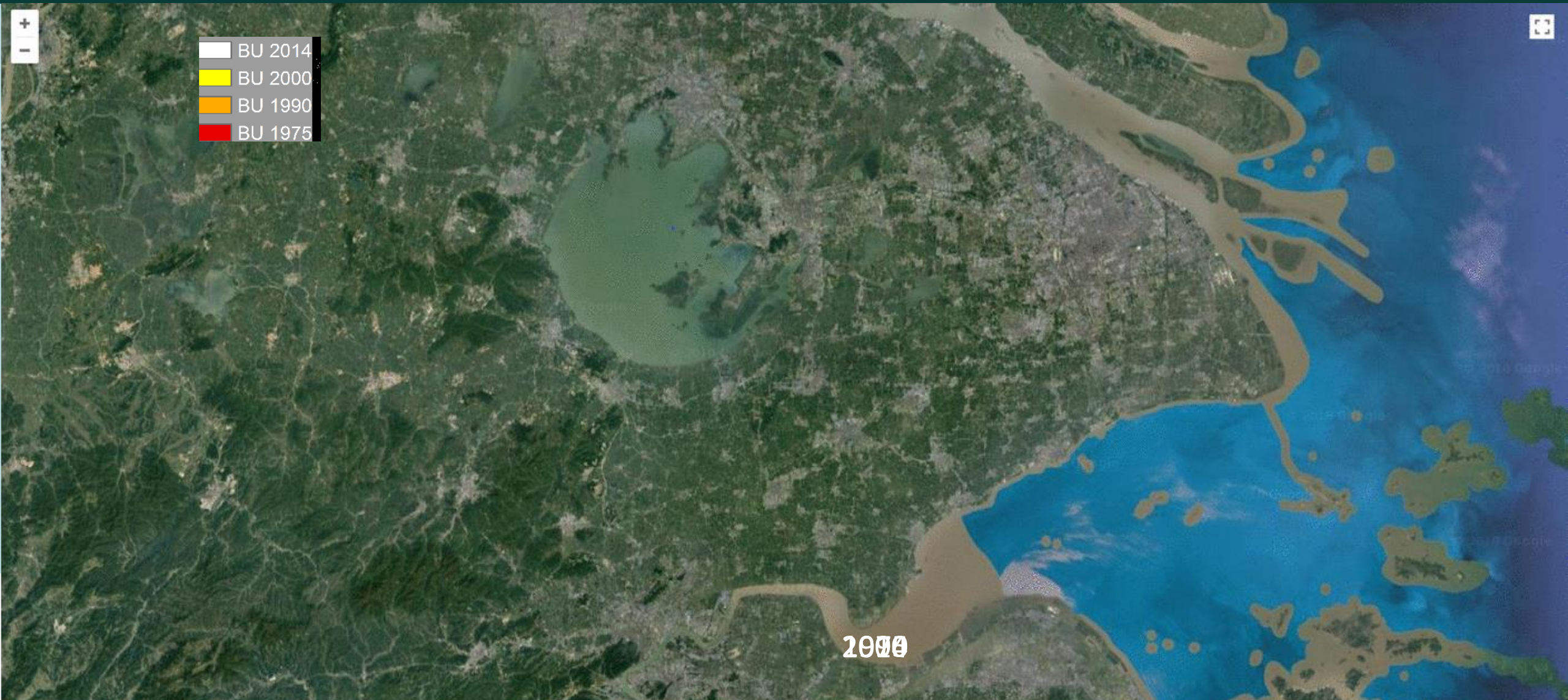
 Download citation

 <https://doi.org/10.1080/20964471.2019.1625528>

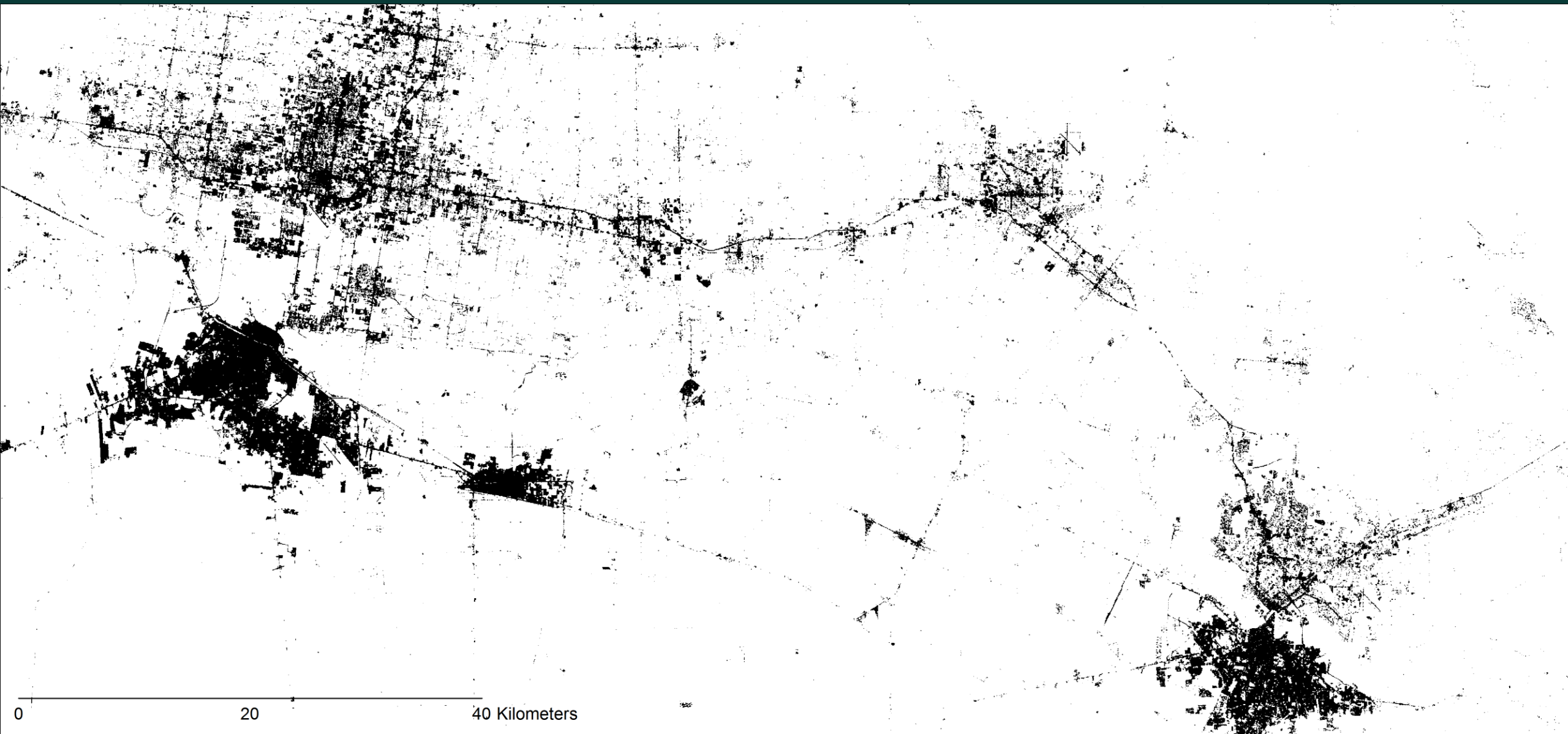


GHS-BUILT – 30m – 250m – 1km

40 years of settlement evolution (1975-1990-2000-2014)



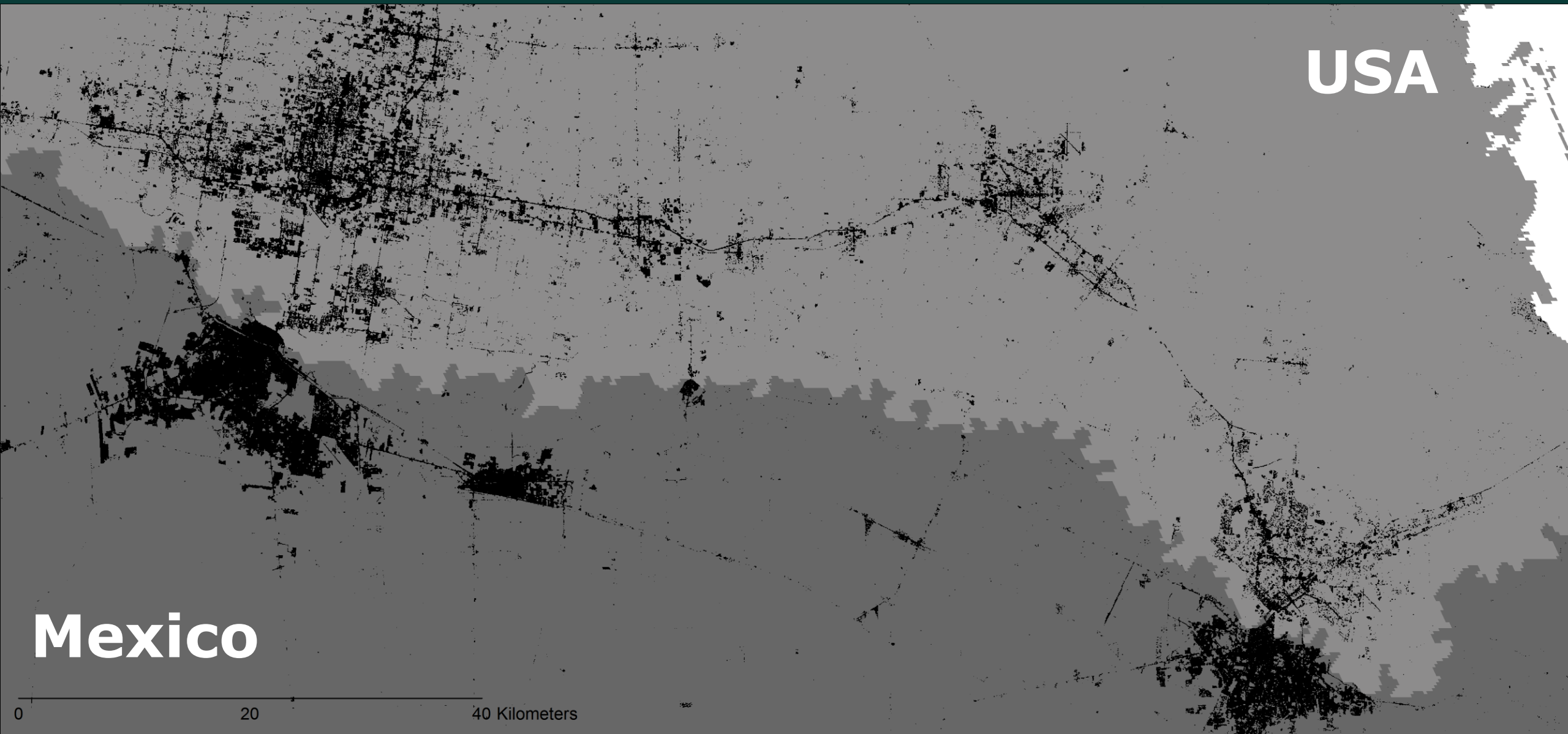
Highlight different settlement morphologies



USA

Mexico

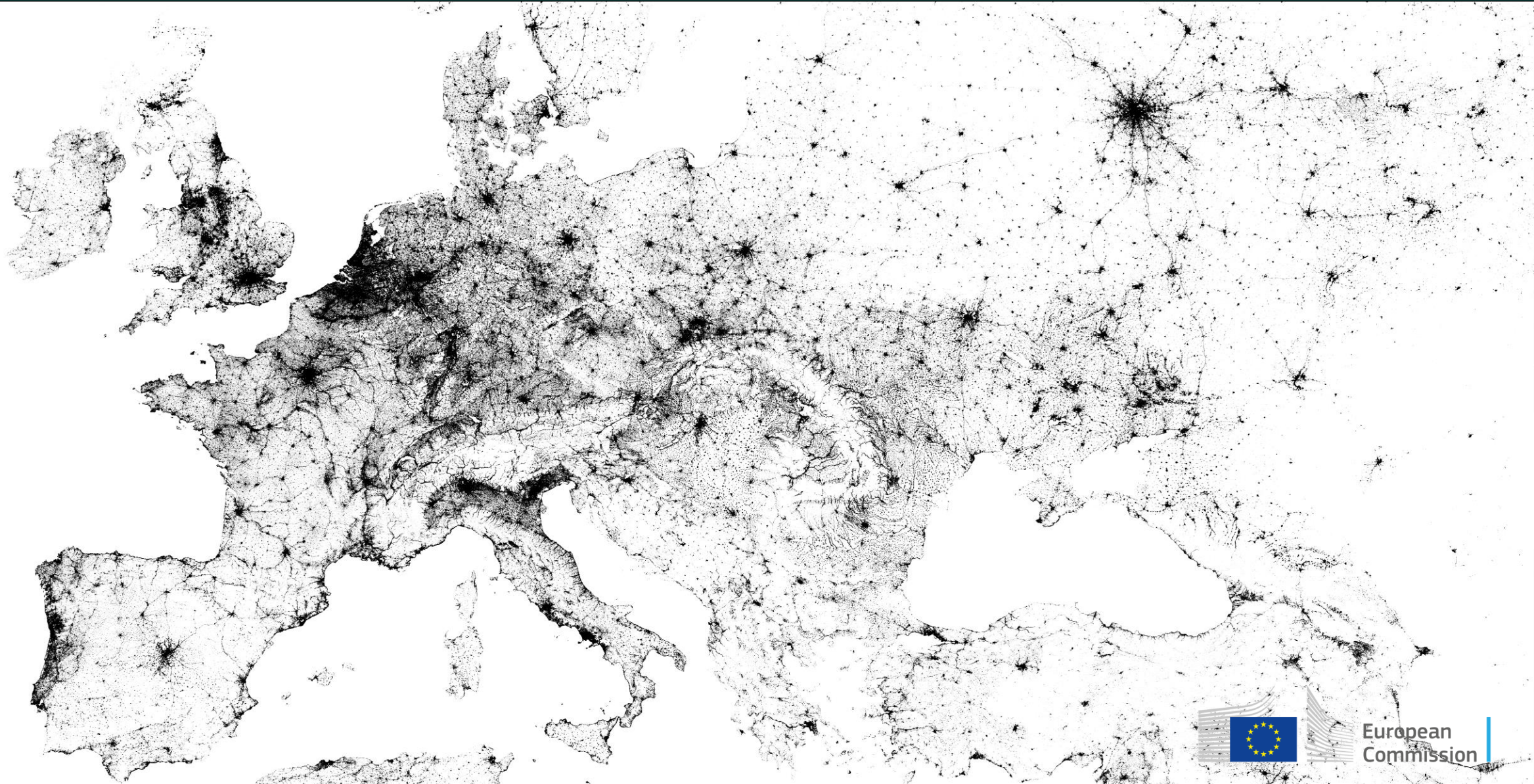
0 20 40 Kilometers



USA east west cleavage in settlement structure density and network



Primacy and Polycentric

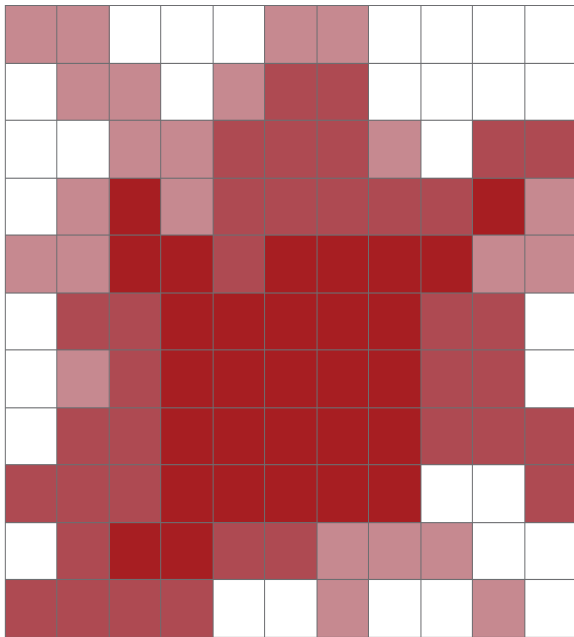


GHSL: a data family

A new population grid (GHS-POP)

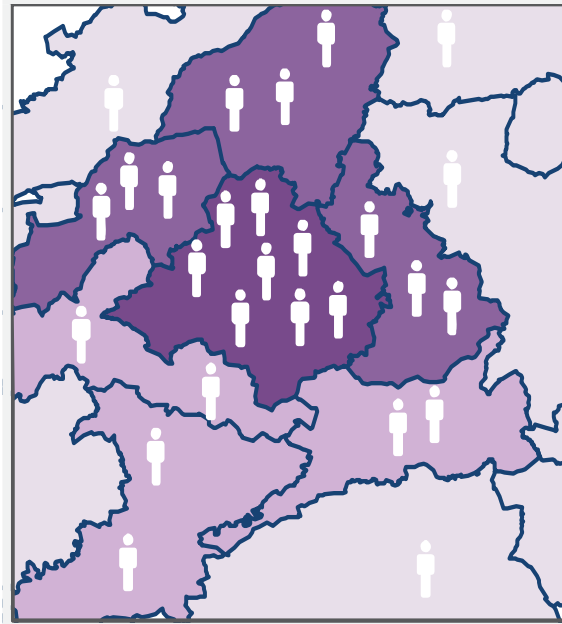


% of land covered by built-up, based on satellite imagery



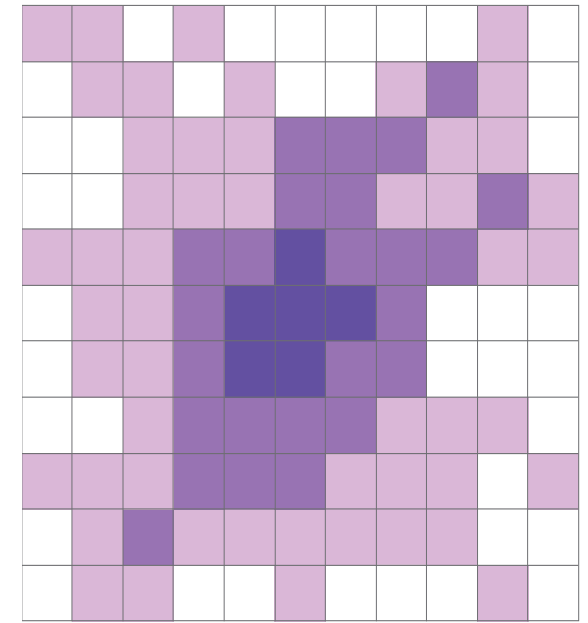
Source: JRC GHS-BU

Population census



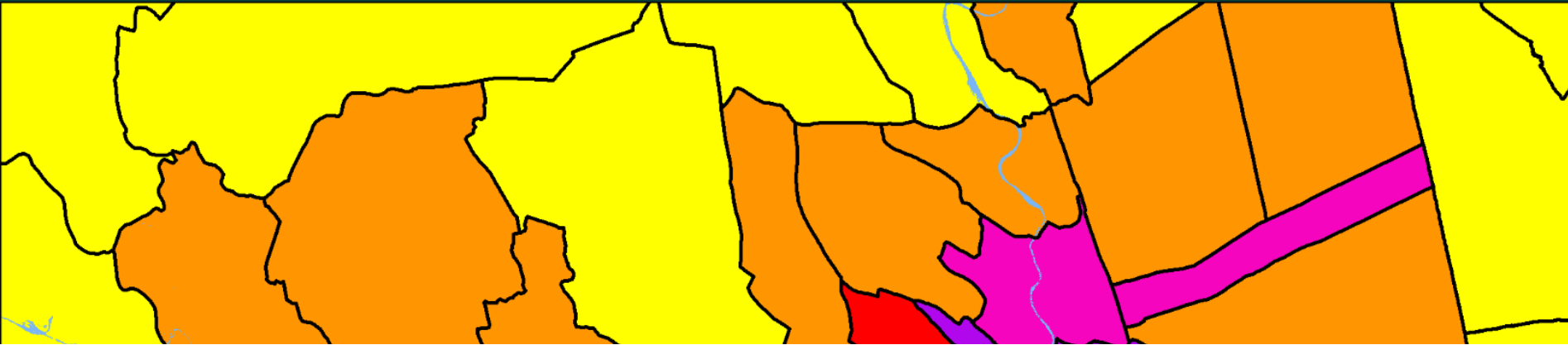
Source: CIESIN,
Columbia University

Population grid



Source: JRC GHS Pop

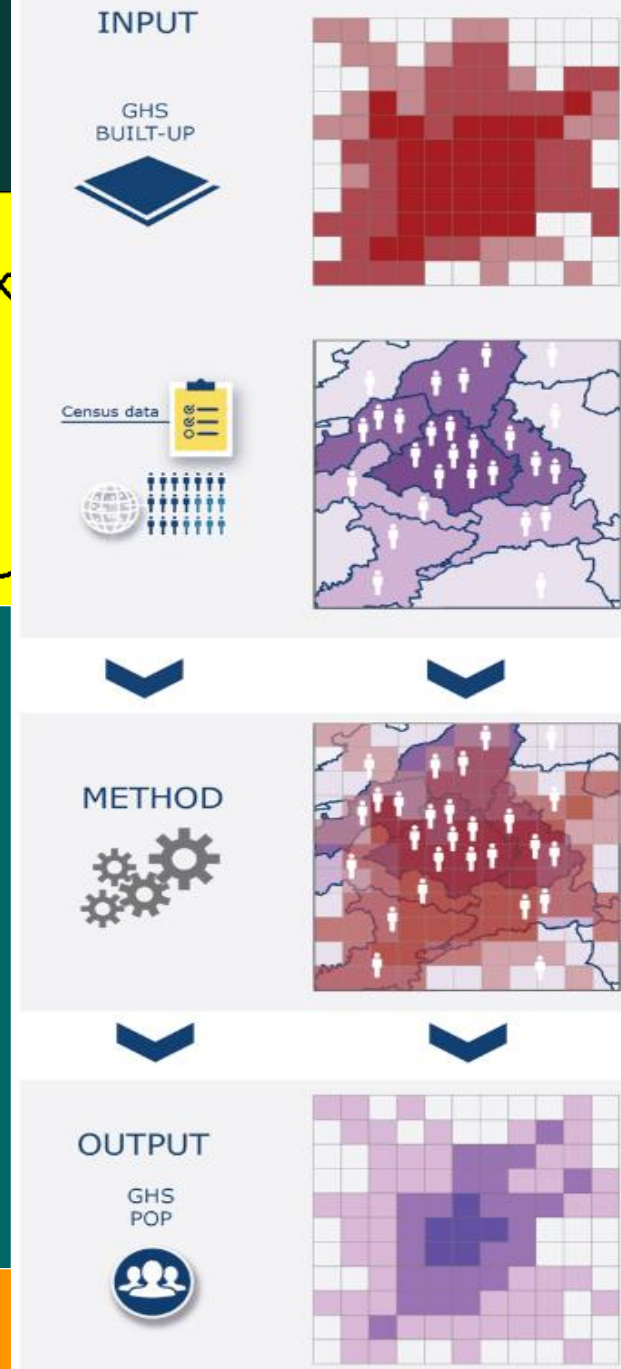
Census units



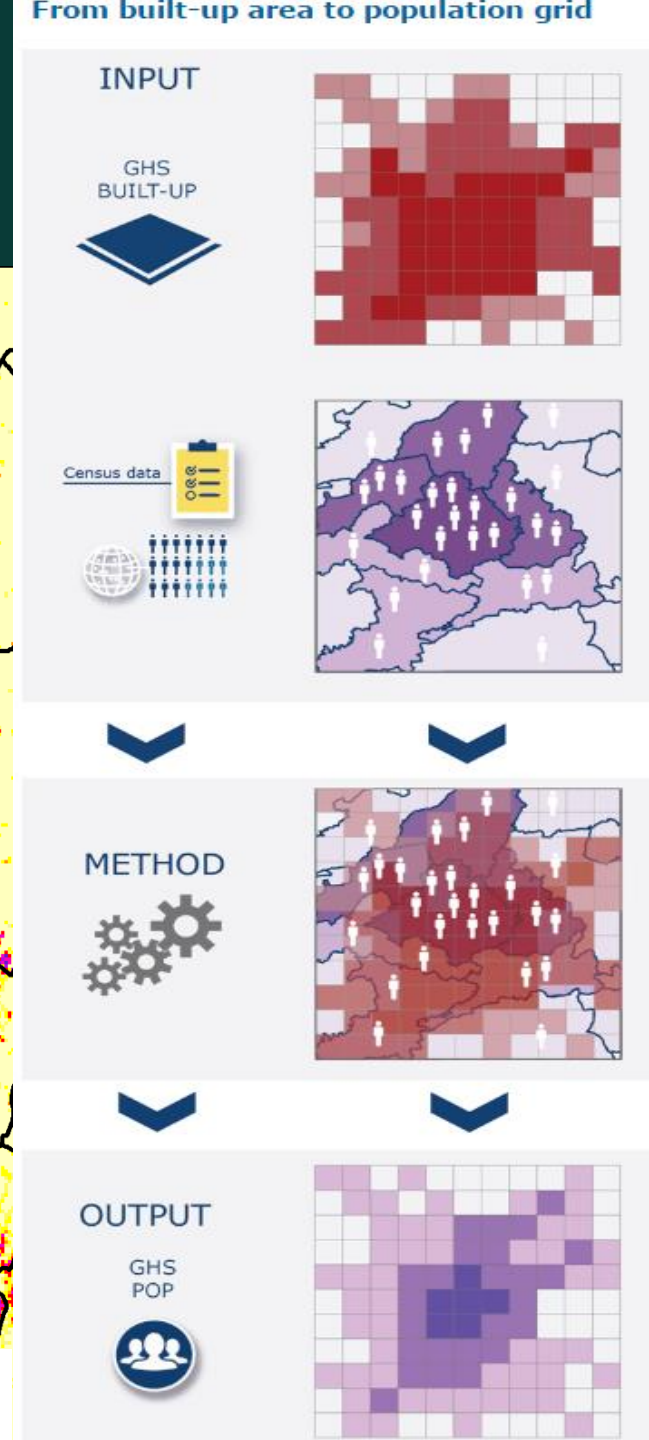
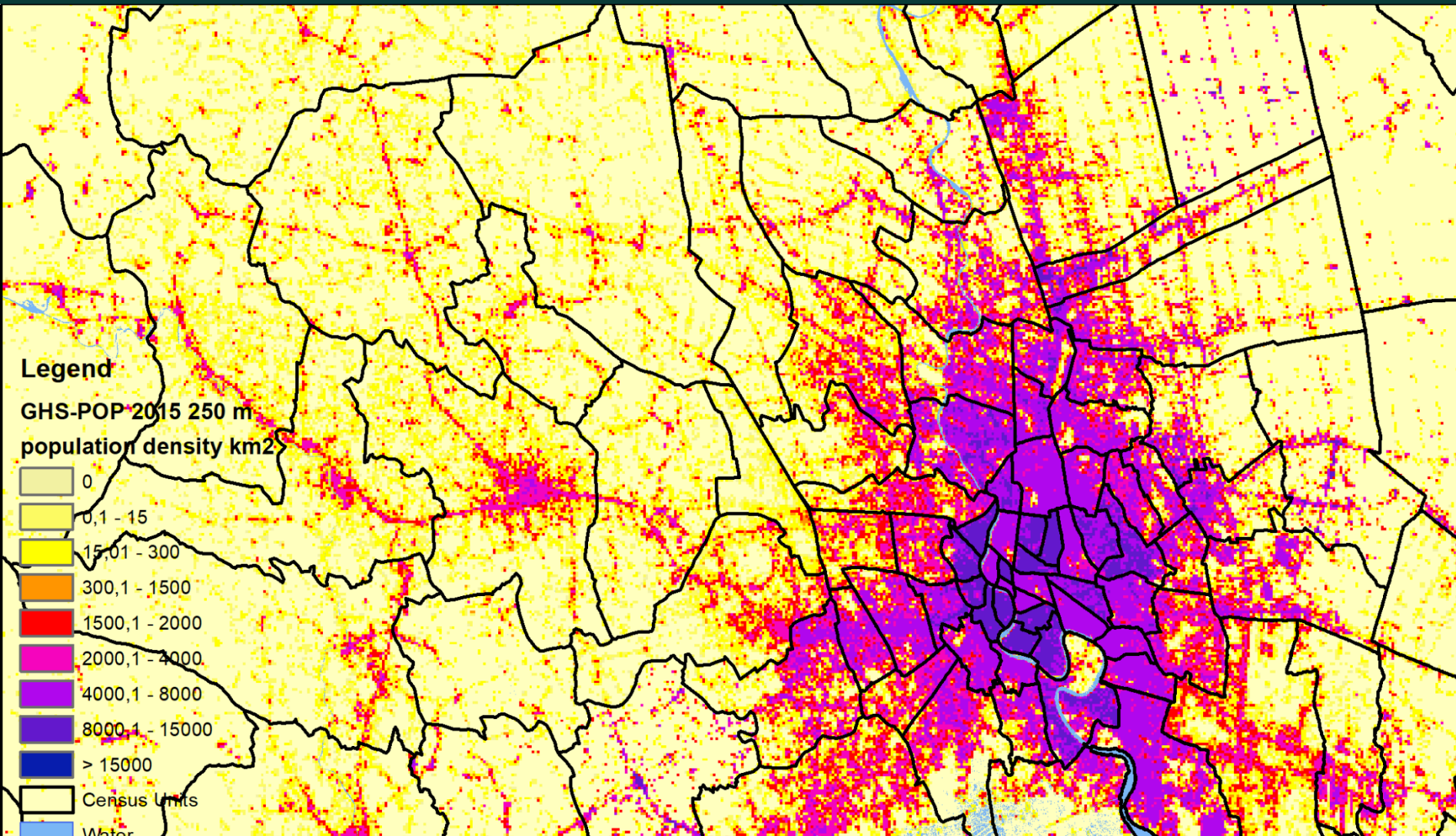
- Lack of spatial detail (i.e. too coarse or generalized, census units)
- Low spatial accuracy (i.e. units partially displaced or completely misplaced)
- Undercounting or Over-counting and/or over-reporting (i.e. overenumeration)



From built-up area to population grid

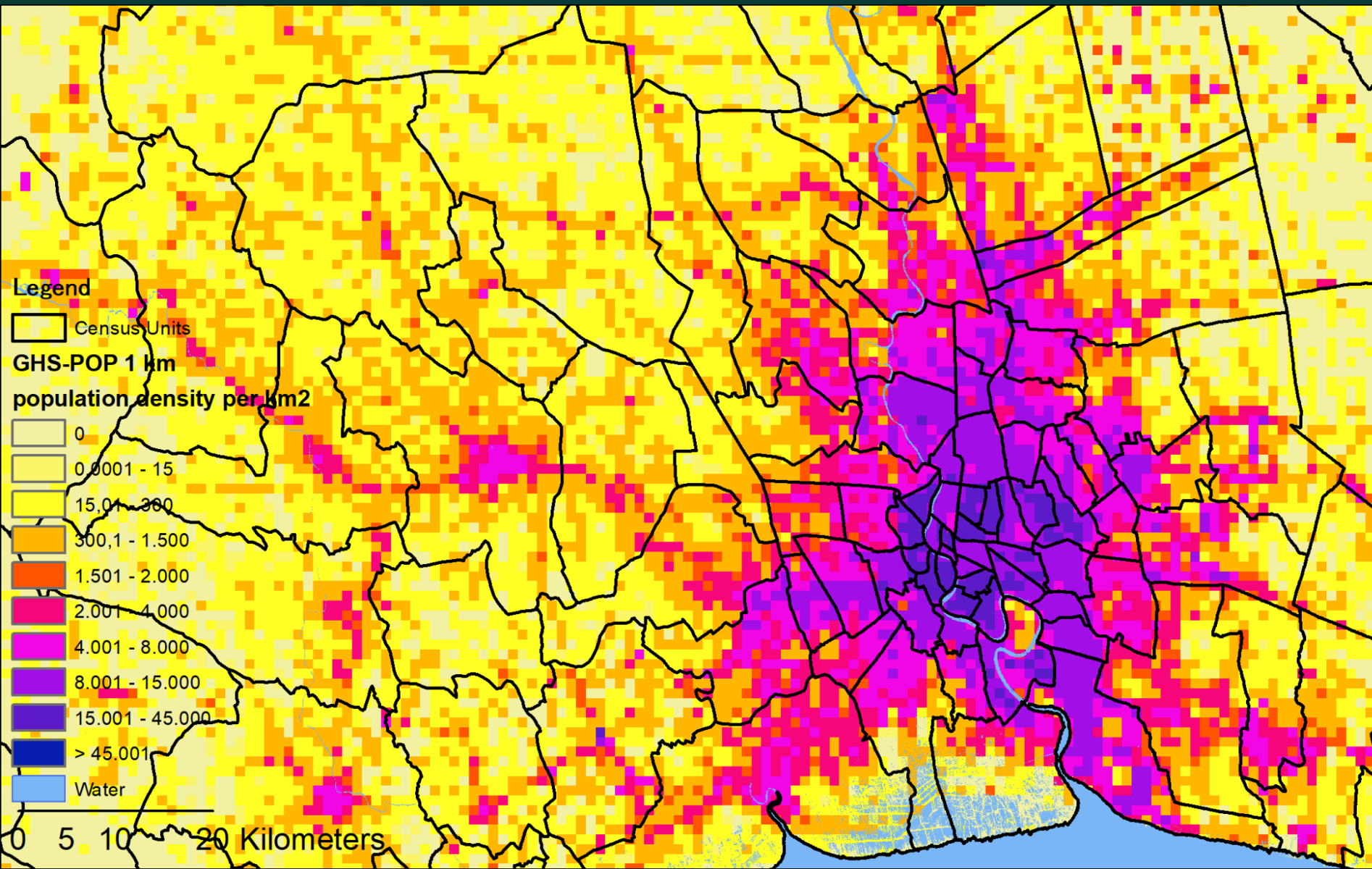


Population GHS-POP



Freire S., Schiavina M., Florczyk A., MacManus K., Pesaresi P., Corbane C., & Richard Sliuzas (2018) Enhanced data and methods for improving open and free global population grids: putting 'leaving no one behind' into practice, *International Journal of Digital Earth*, DOI: 10.1080/17538947.2018.1548656

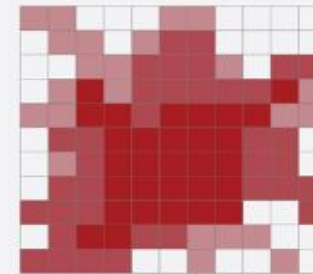
Population GHS-POP – 250m – 1km multitemporal 1975 – 1990 – 2000 – 2015



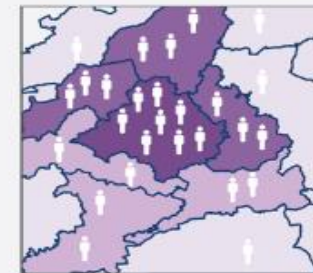
From built-up area to population grid

INPUT

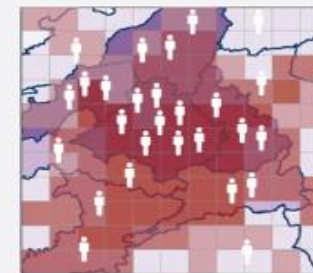
GHS
BUILT-UP



Census data

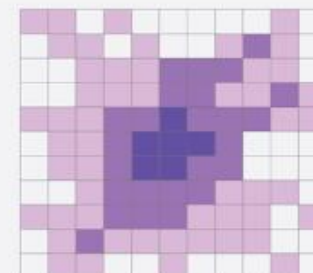


METHOD

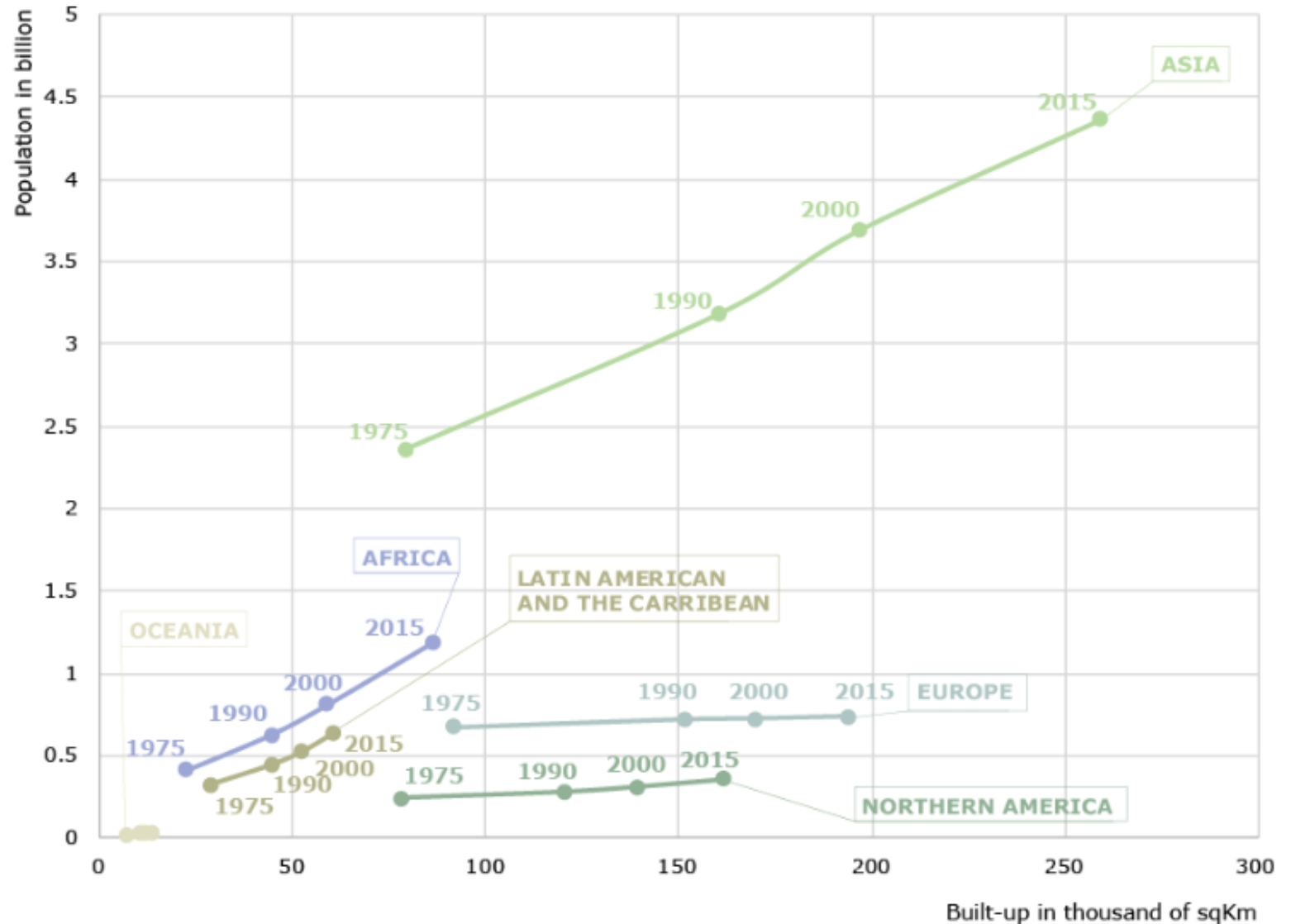
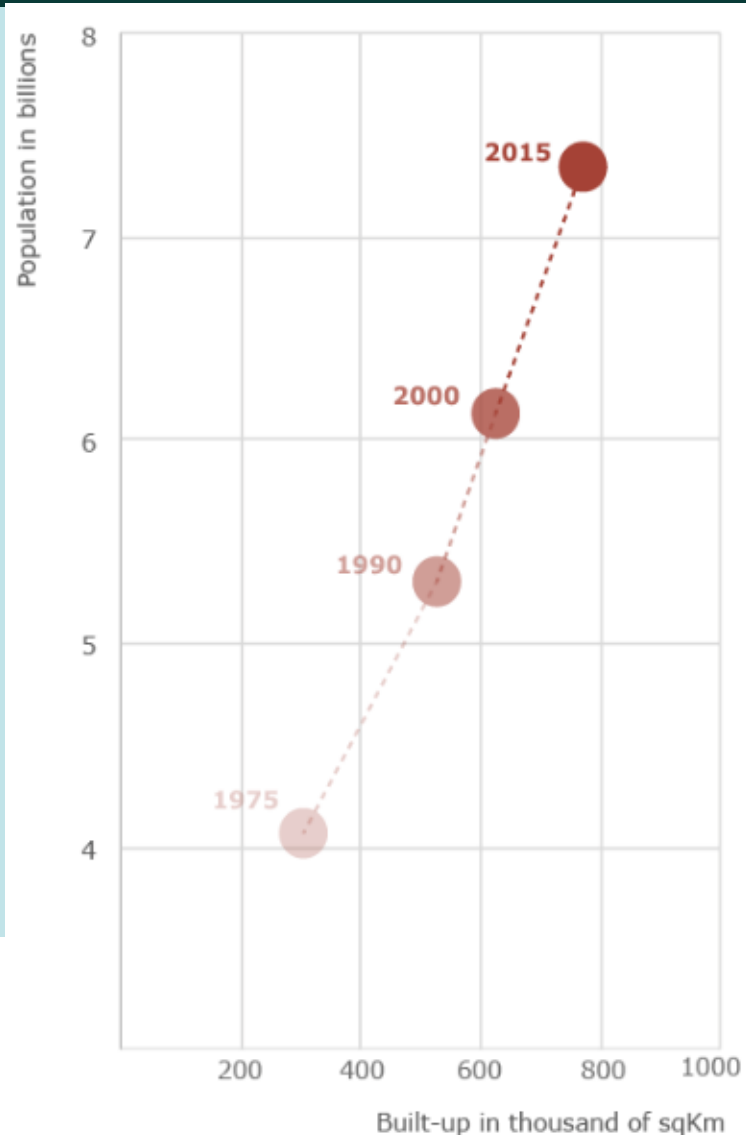


OUTPUT

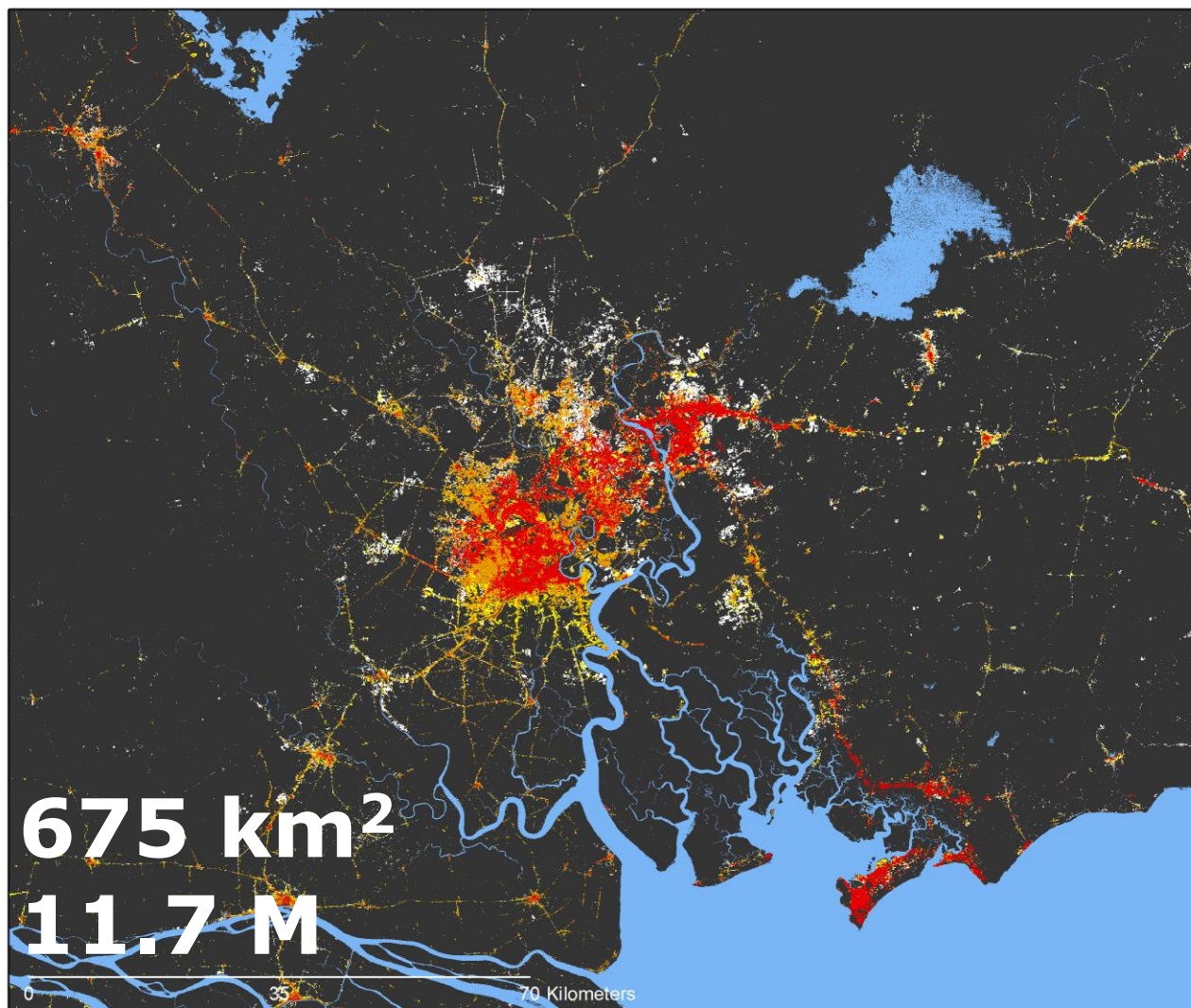
GHS
POP



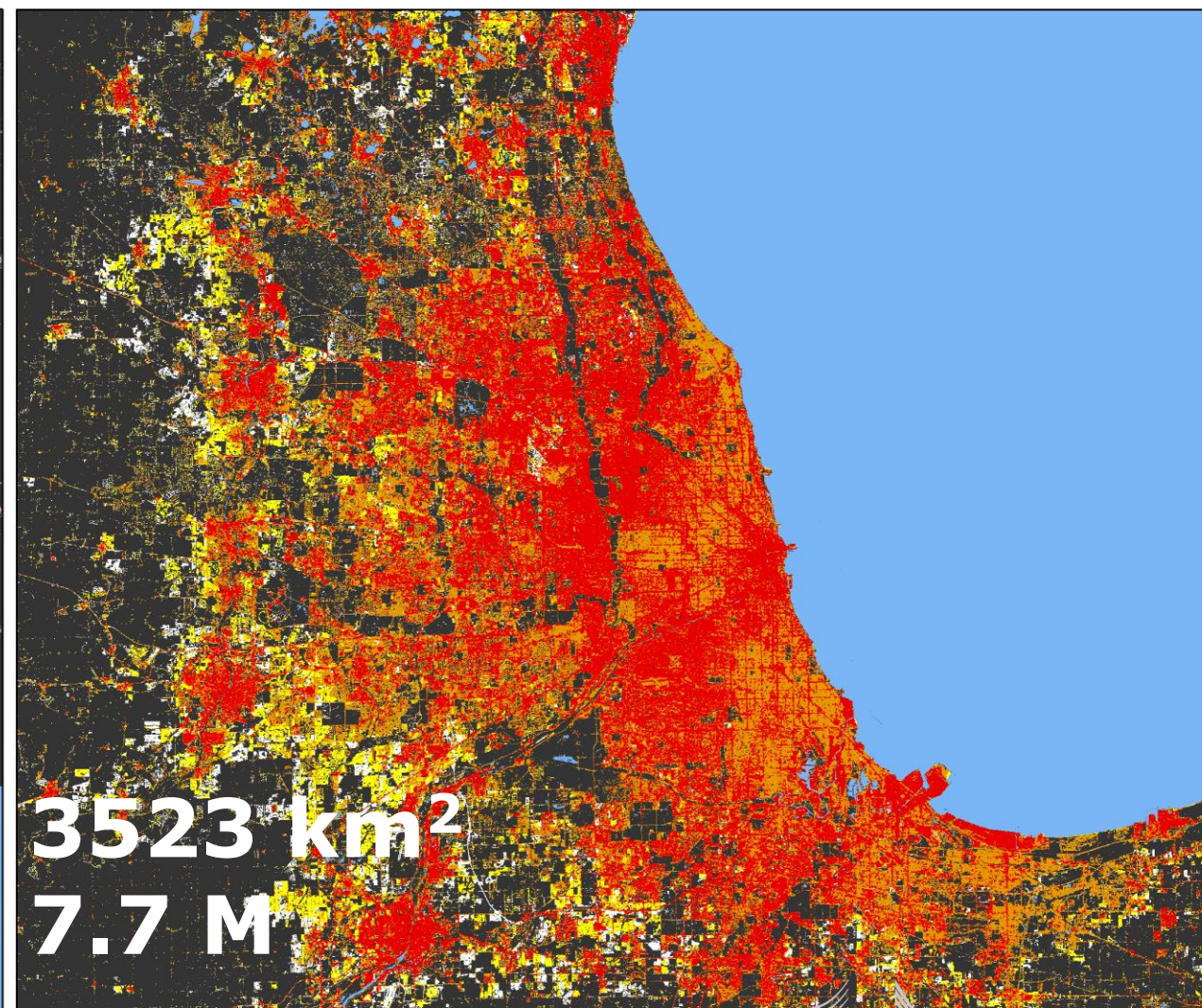
1975-2015 societal variables trends: **+50%** built-up area - **+100%** Population



Comparisons



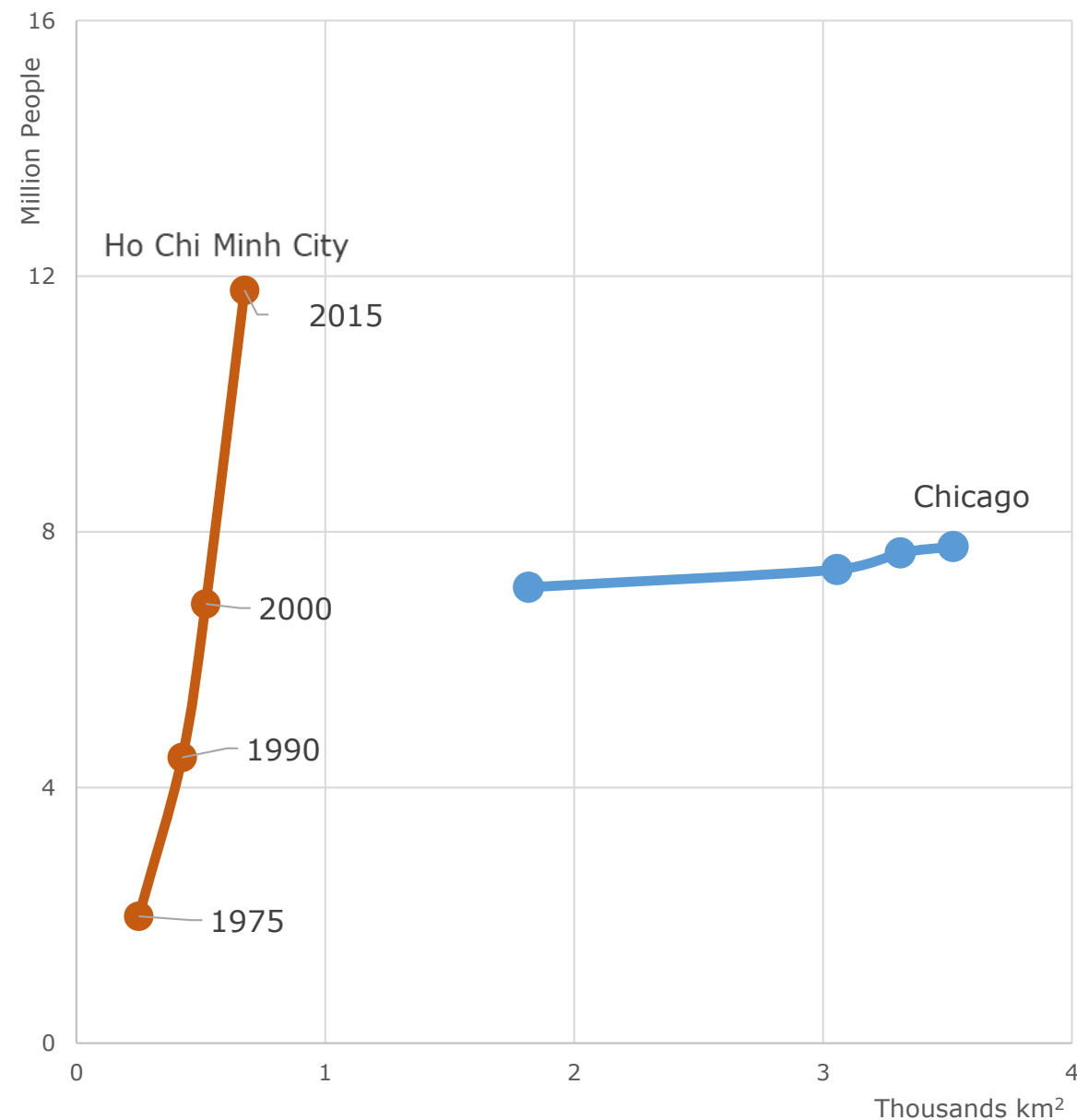
Ho Chi Minh City, Viet Nam



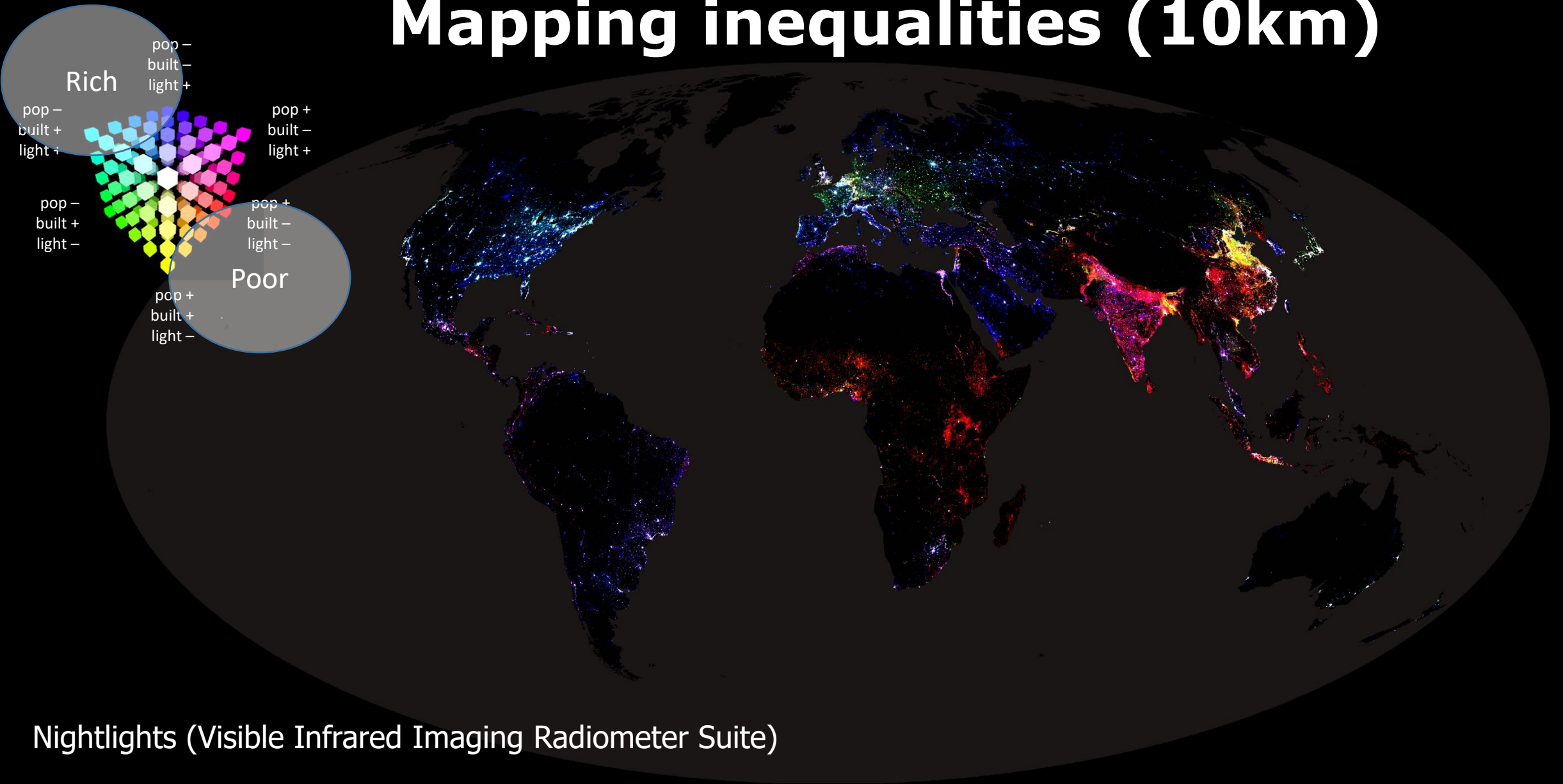
Chicago, USA

Sociospatial patterns of change 1975-2015

	Population	Built-up Areas
Ho Chi Minh City	6x	3x
Chicago	1x	2x



Mapping inequalities (10km)

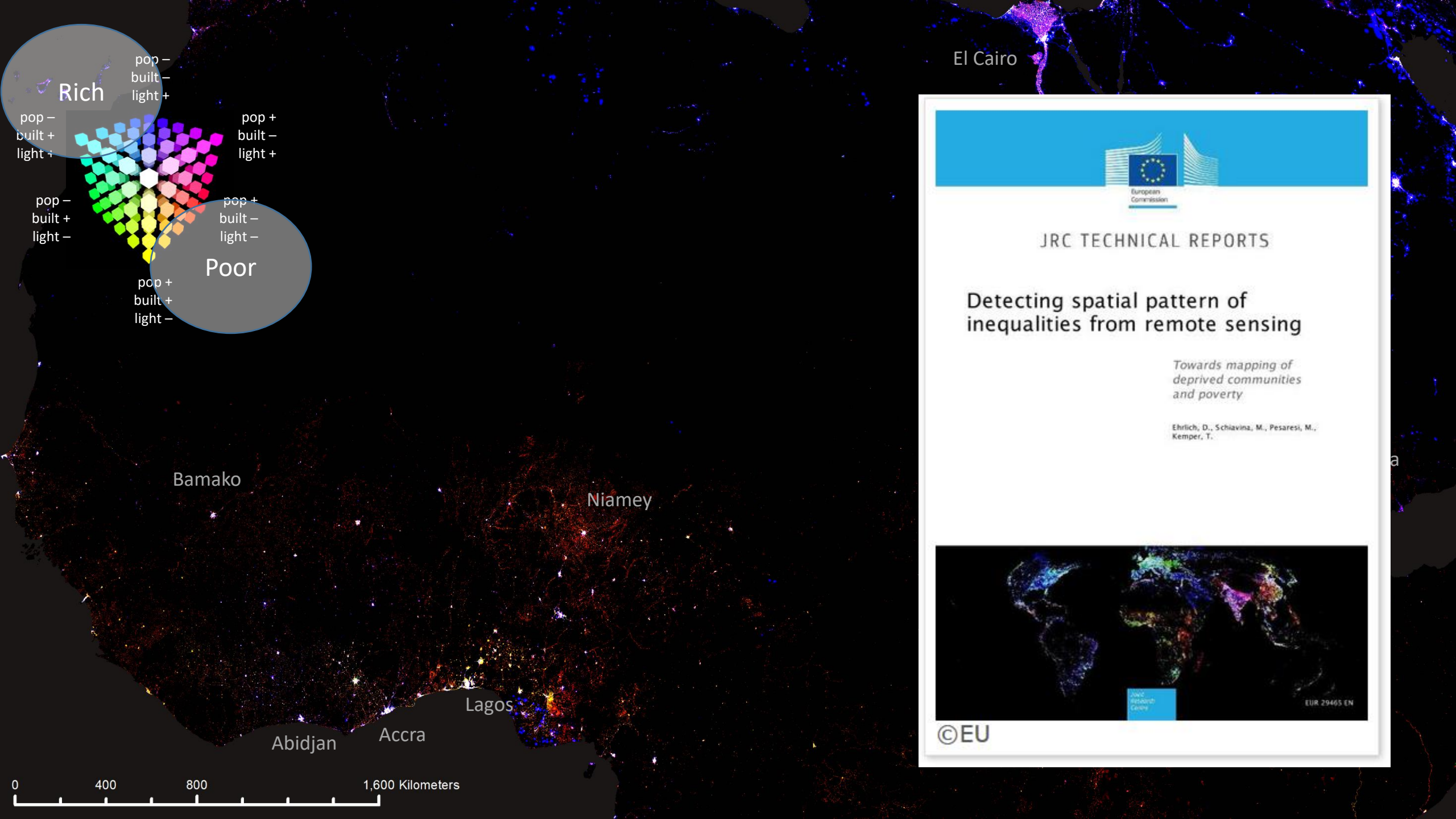


Nightlights (Visible Infrared Imaging Radiometer Suite)

+

GHSL (population and built-up surfaces)

0 2,500 5,000 10,000 Kilometers



El Cairo



JRC TECHNICAL REPORTS

Detecting spatial pattern of inequalities from remote sensing

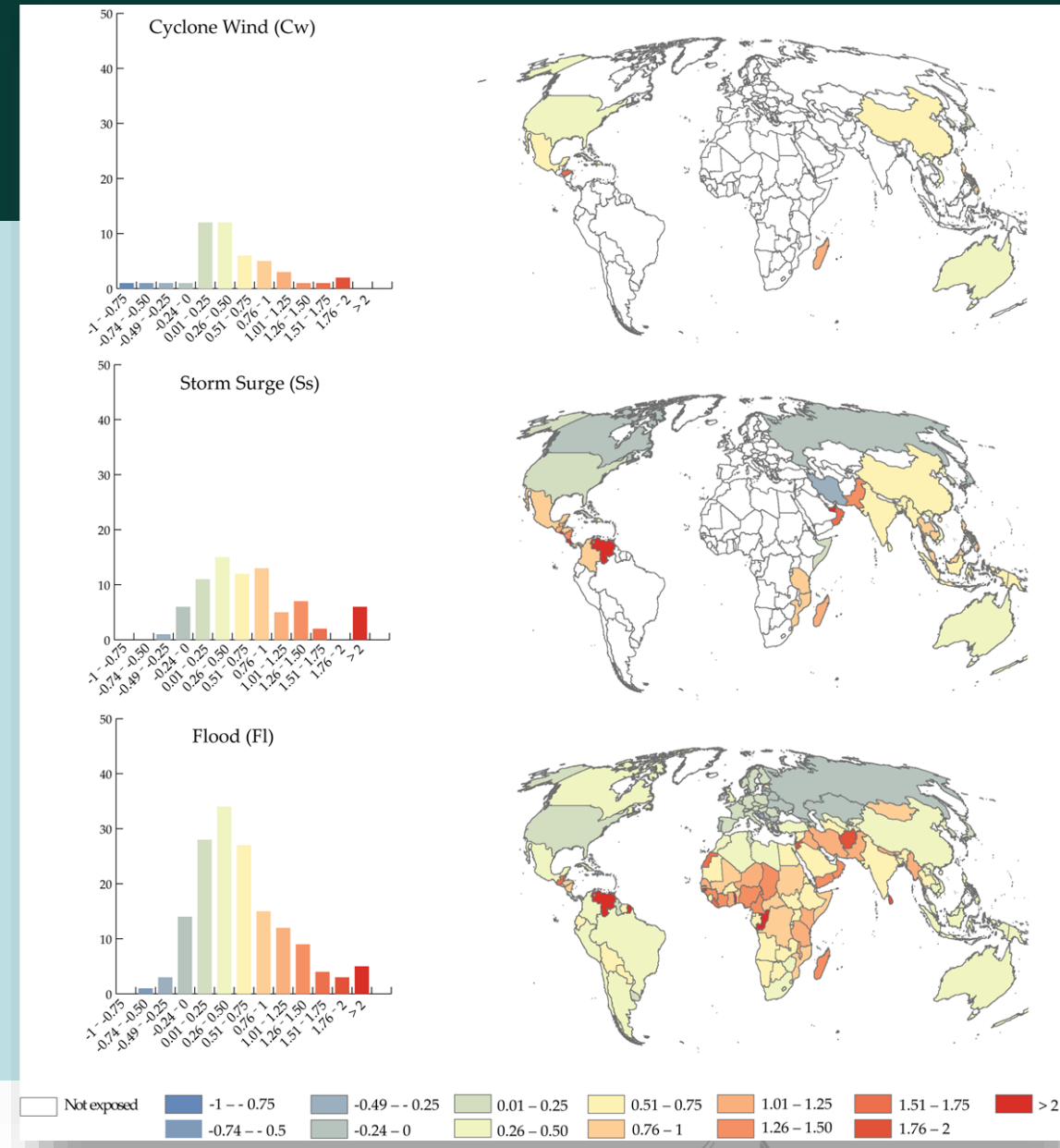
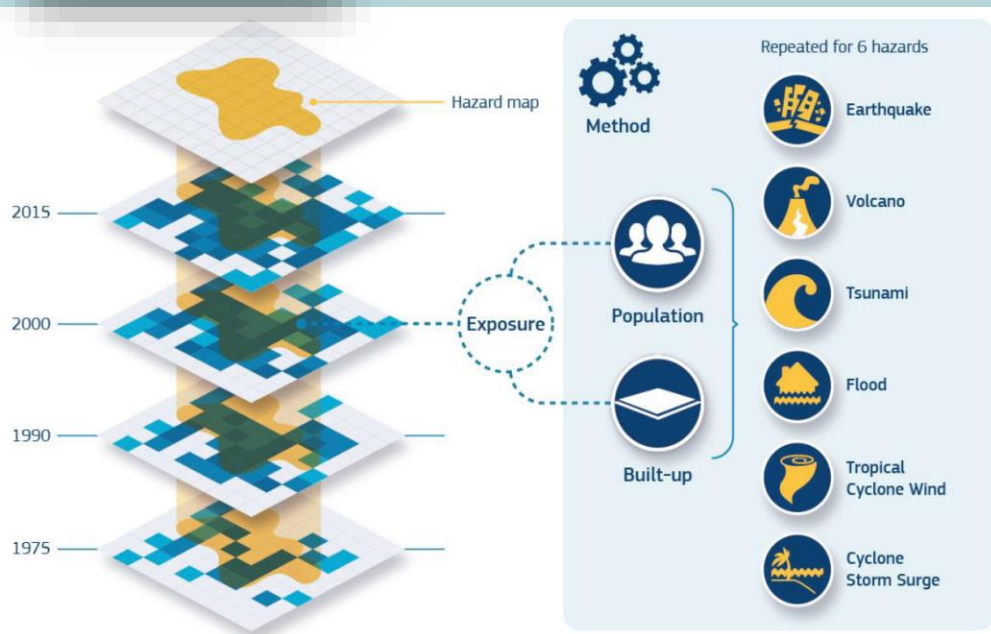
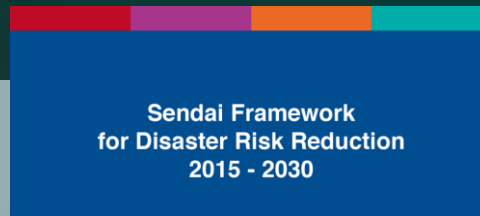
Towards mapping of deprived communities and poverty

Ehrlich, D., Schiavina, M., Pesaresi, M., Kemper, T.



©EU

Exposure to natural hazards



Ehrlich, D.; Melchiorri, M.; Florczyk, A.J.; Pesaresi, M.; Kemper, T.; Corbane, C.; Freire, S.; Schiavina, M.; Siragusa, A. Remote Sensing Derived Built-Up Area and Population Density to Quantify Global Exposure to Five Natural Hazards over Time. Remote Sens. 2018, 10, 1378.



Developing a global, people-based definition of cities and rural areas

- **Cooperation started in 2016 at Habitat III**
- **Discussed at plenary of UN Statistical Commission (UNSC) July 2019**
- **(possibly) adopted by UNSC in March 2020**

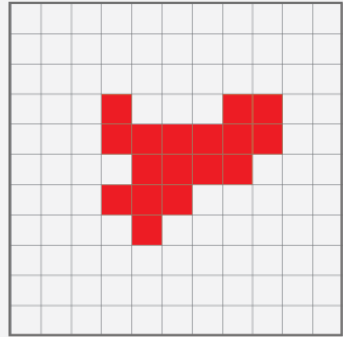


Where does a city stop?



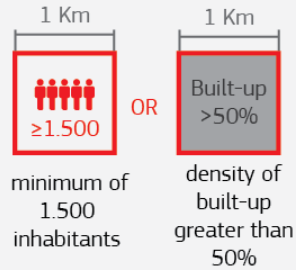
The Settlement Model (GHS-SMOD) based on the Degree of Urbanization (DEGURBA)

URBAN CENTRE

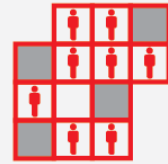


Required conditions

EACH GRID CELL



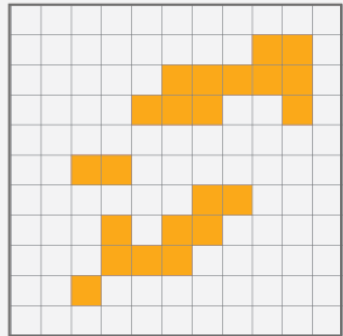
AND



TOTAL POPULATION
≥ 50.000
INHABITANTS

contiguous grid cells
(4-connectivity, gap filling) with
minimum population of 50.000
inhabitants

URBAN CLUSTER



Required conditions

EACH GRID CELL



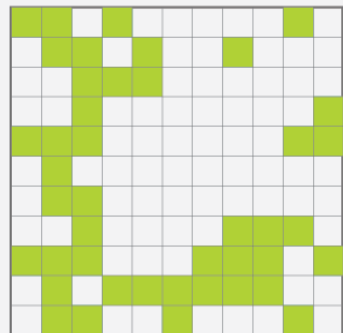
AND



TOTAL POPULATION
≥ 5.000
INHABITANTS

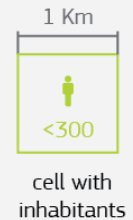
contiguous grid cells
(8-connectivity)
with minimum population of 5.000
inhabitants

RURAL



Required conditions

EACH GRID CELL



Urban
centres

Urban centres

Urban
Clusters

Dense urban cluster

Semi-dense Urban Cluster

Suburbs

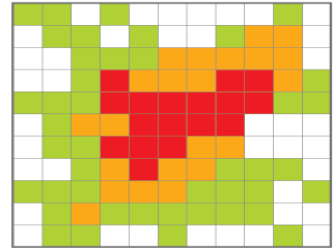
Rural clusters

Rural

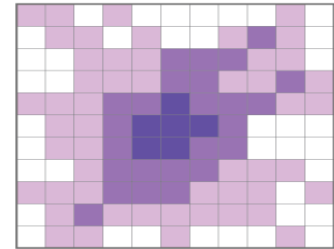
Low density

Very low density

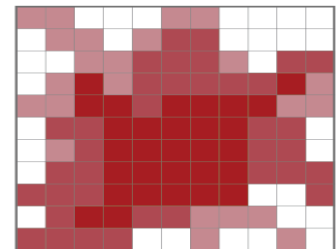
S-MOD
calculated at 1Km



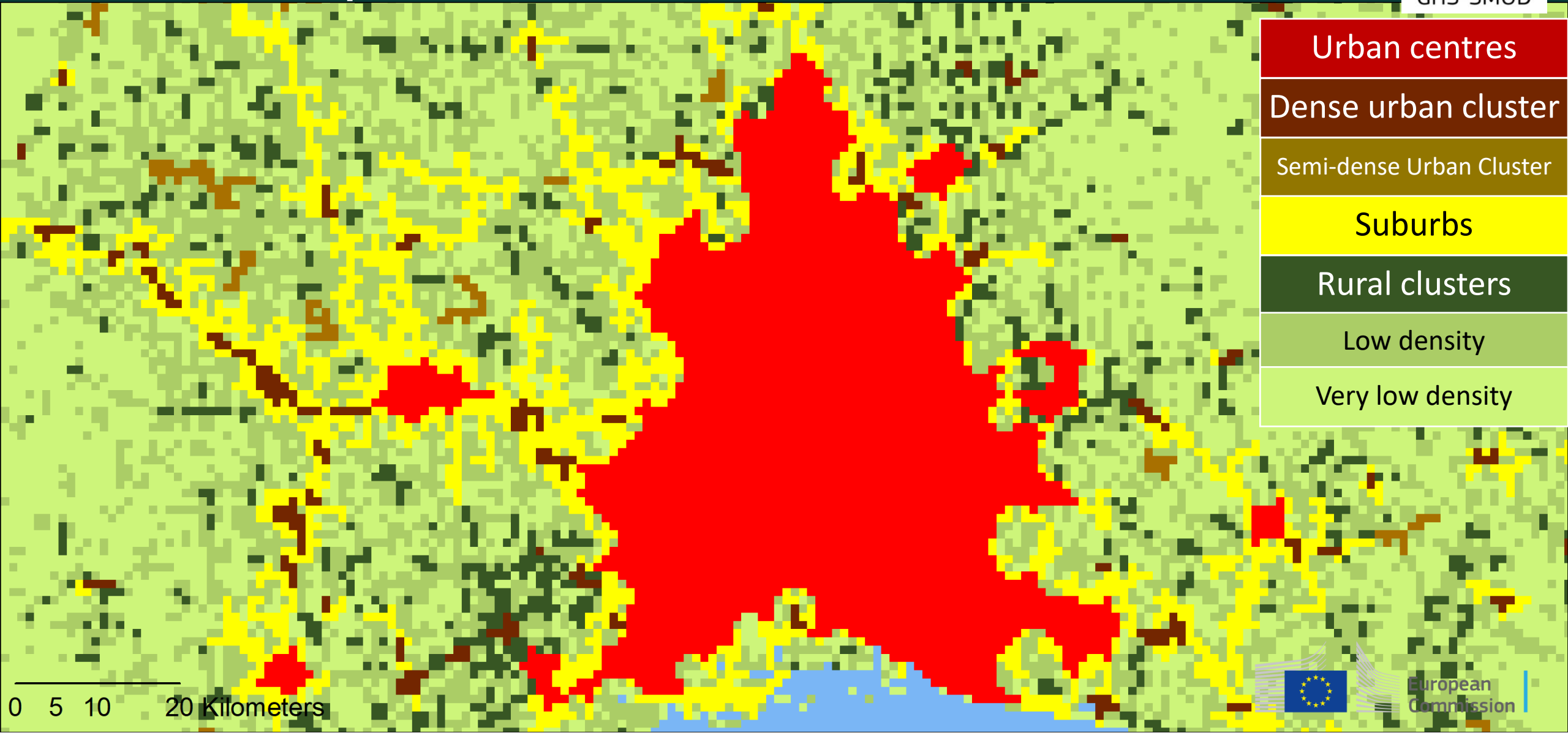
POPULATION GRID
aggregated from 250m



BUILT-UP
aggregated from 38m



GHS-SMOD Settlement Model – 1km multitemporal 1975 – 1990 – 2000 – 2015



Urban centres

Dense urban cluster

Semi-dense Urban Cluster

Suburbs

Rural clusters

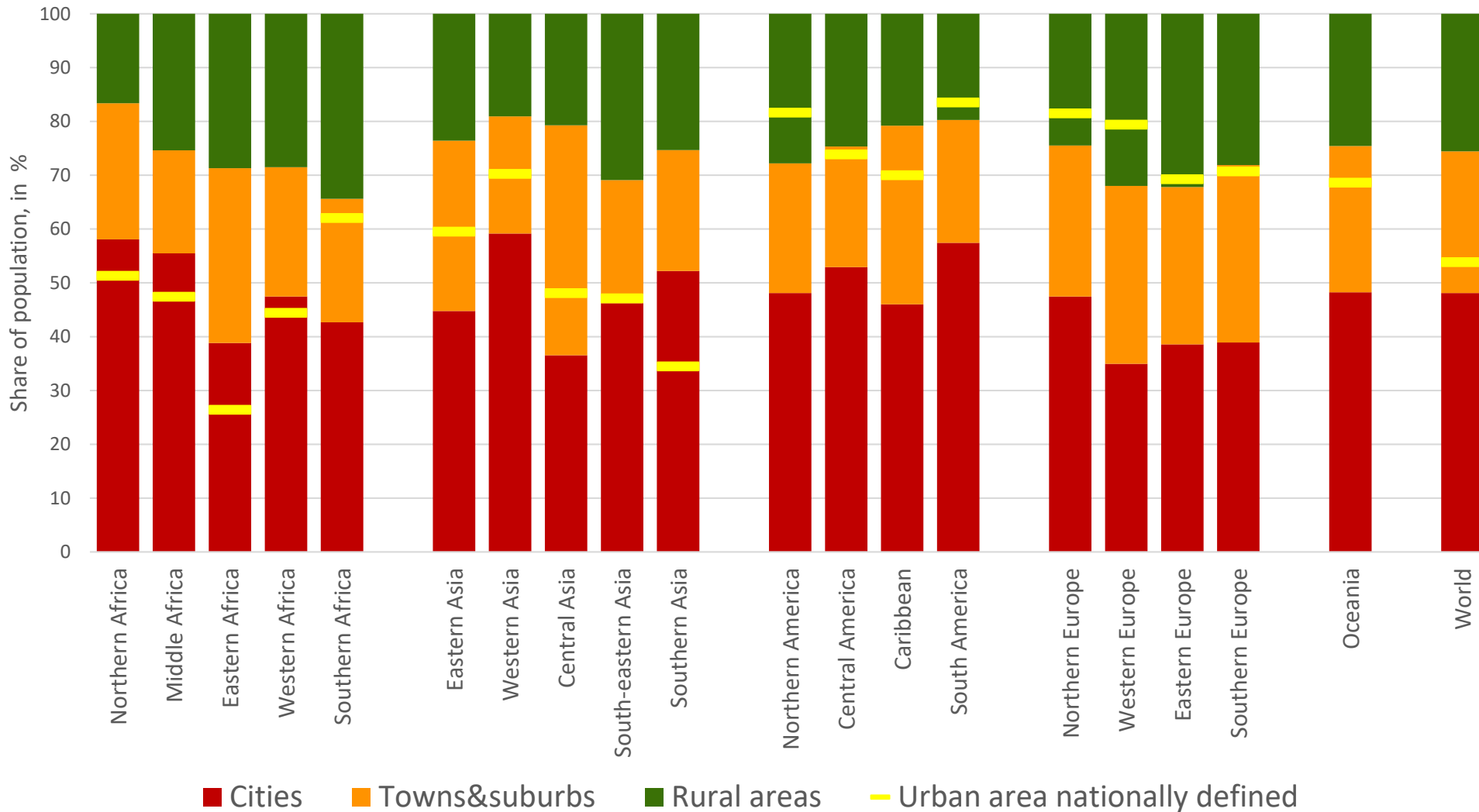
Low density

Very low density

0 5 10 20 Kilometers

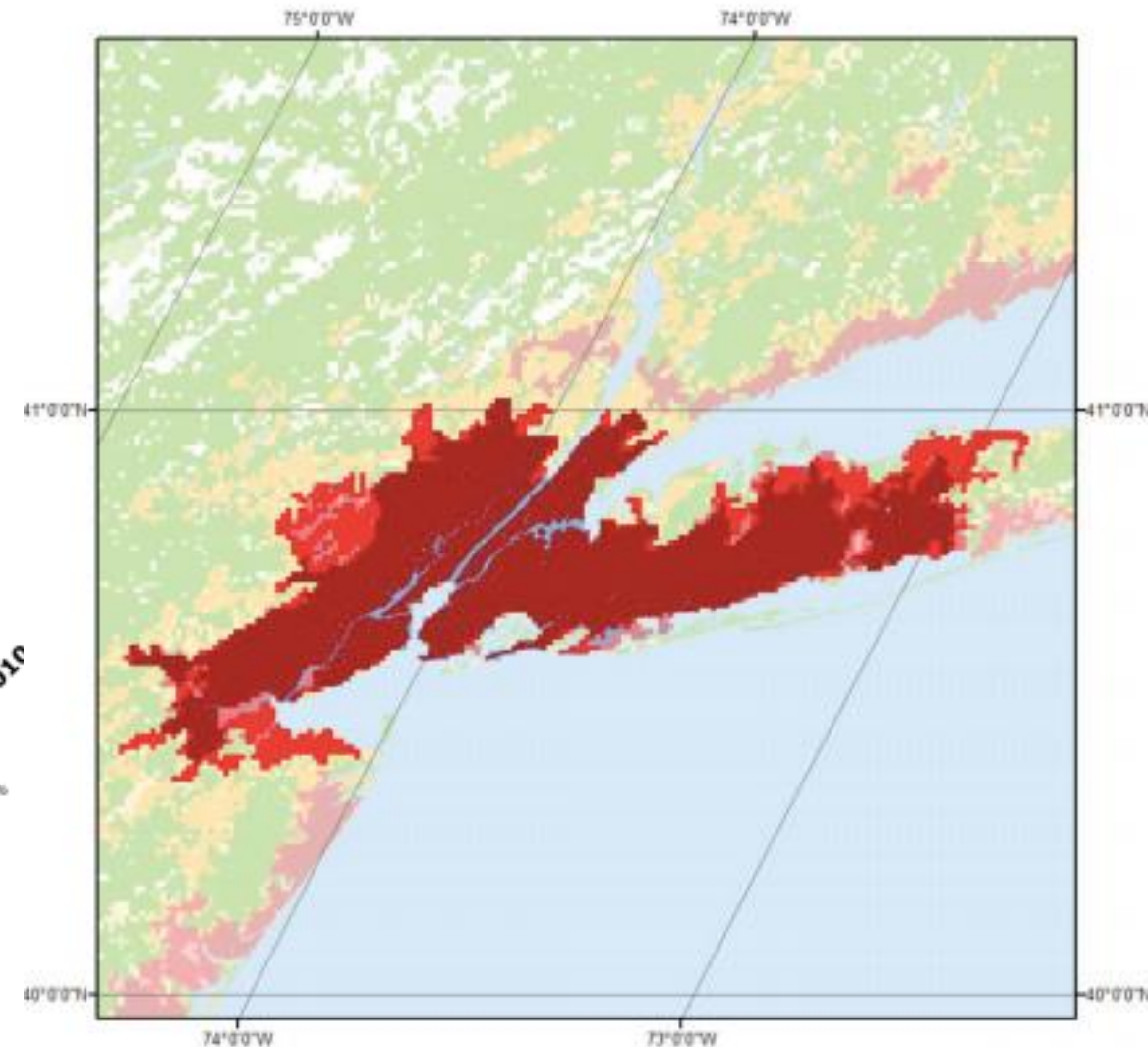
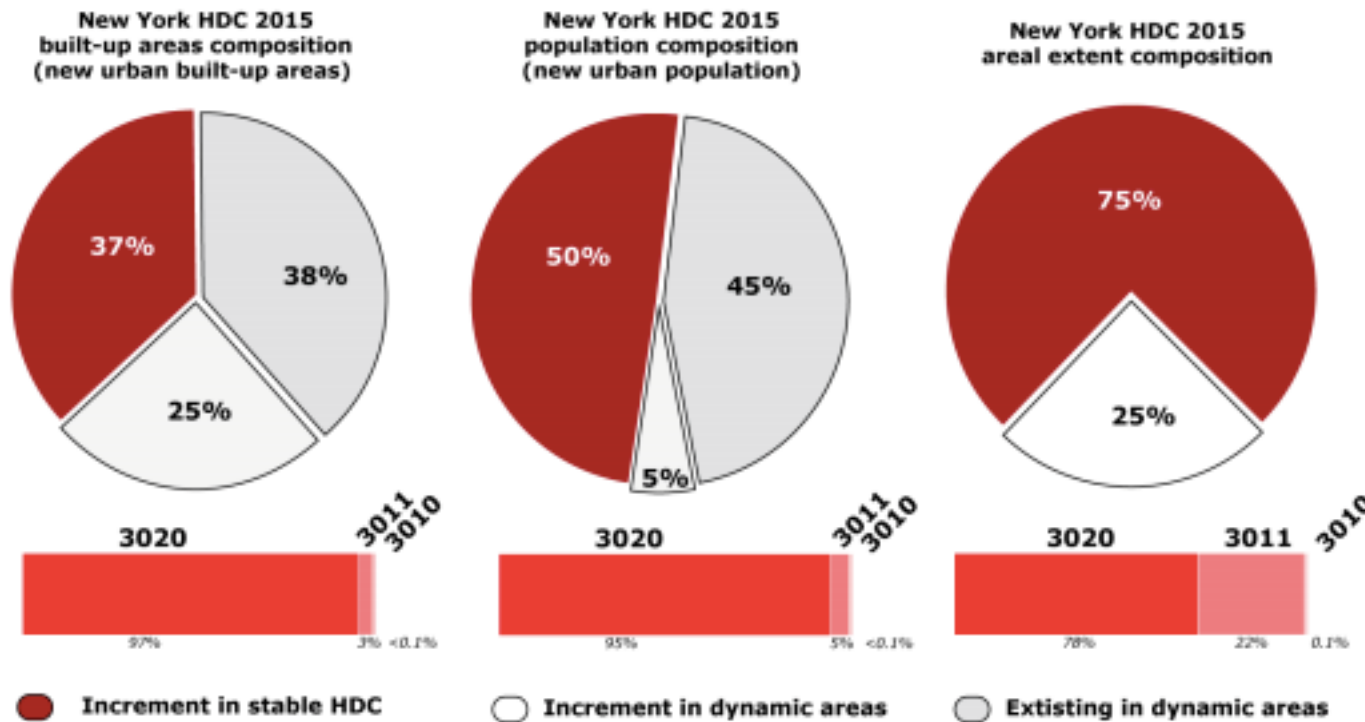


A new view on global urbanisation



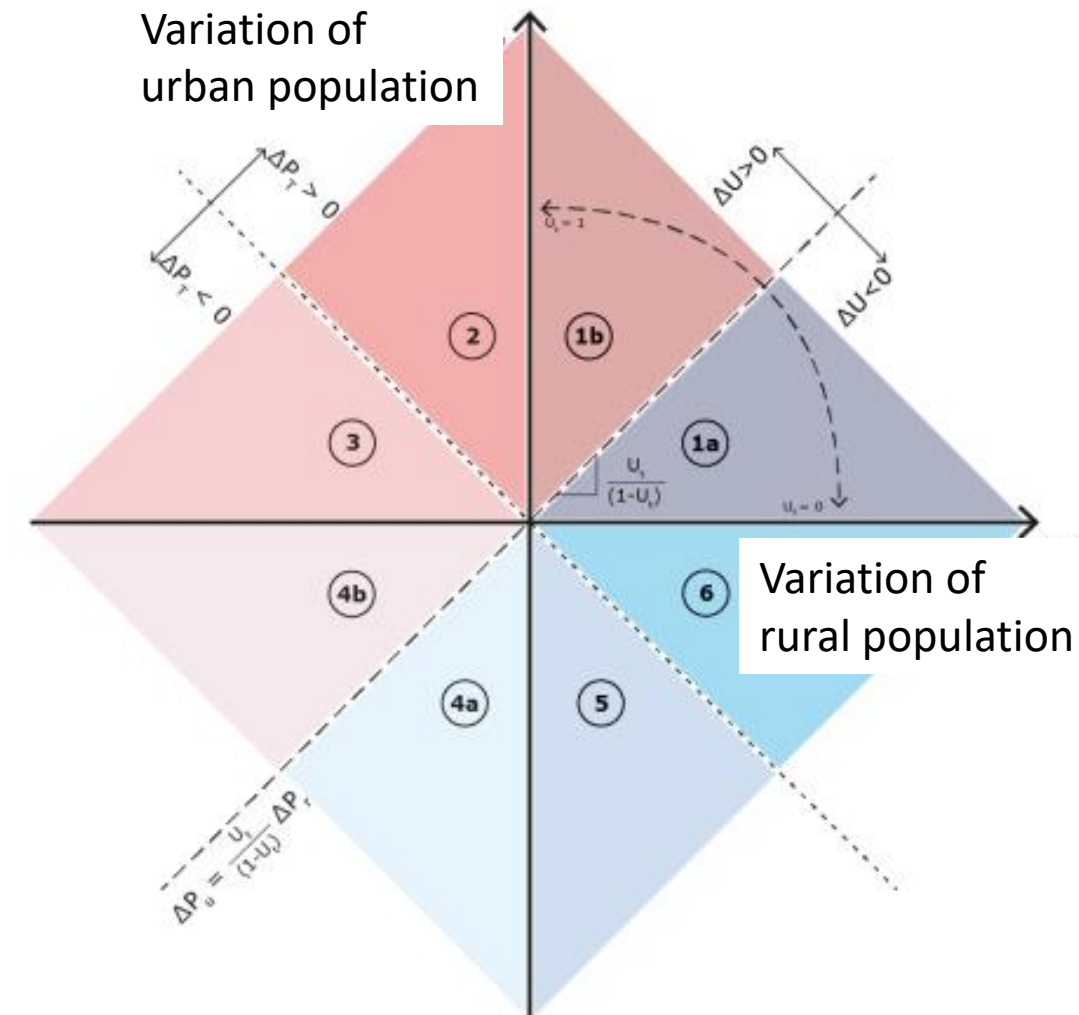
Global urbanisation rate with the new definition is more than 75%

Settlement multitemporal analysis: gross and net growth



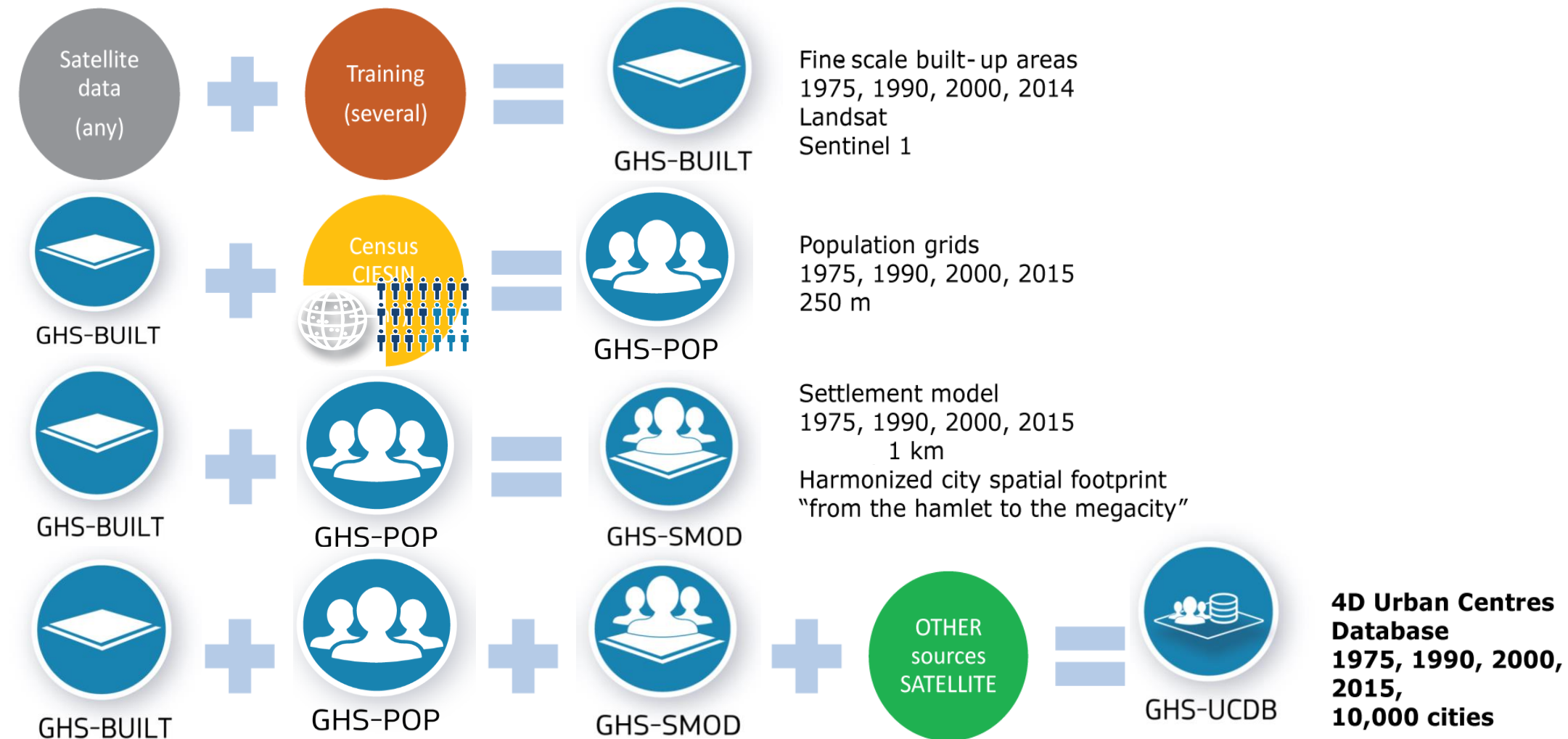
Urbanisation dynamics: demographic factors of change

Classification	Name
1a	<i>Rural driven de-urbanisation and demographic growth</i>
1b	<i>Urban driven urbanisation and demographic growth</i>
2	<i>Urban polarised urbanisation and demographic growth</i> (Pure urban growth)
3	<i>Urban resilient urbanisation and demographic decline</i> (Pure rural decline)
4a	<i>Urban driven de-urbanisation and demographic decline</i>
4b	<i>Rural driven urbanisation and demographic decline</i>
5	<i>Rural resilient de-urbanisation and demographic decline</i> (pure urban decline)
6	<i>Rural polarised de-urbanisation and demographic growth</i> (Pure rural growth)



GHSL: a data family

GHSL Baseline data anatomy



GHS Urban Centres Data Base

10.000 urban centres

Geography

- Elevation
- Travel time to capital
- River basin
- Name of the center
- etc.

Environment

- Climate
- Biome
- Temperature
- Precipitation
- Greenness
- CO₂ concentration
- PM_{2.5} emission and concentration

DRR – exposure to

- Flood
- Earthquake
- Storm surge
- Heatwave

Socio-economic

- Population
- Built-up areas
- GDP
- Development Indicators (UN)
- Nighttime lights

Estimate **2 SDG** indicators
Multi-temporal information
1975-1990-2000-2015



GHS
UCDB

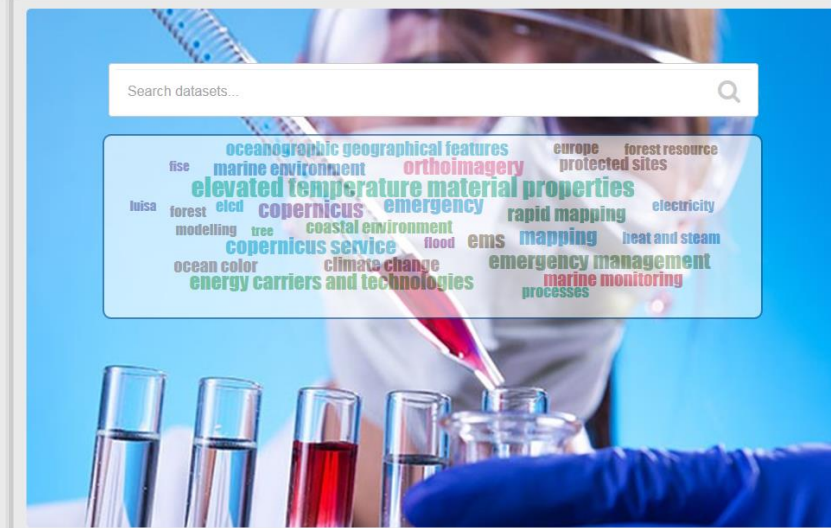
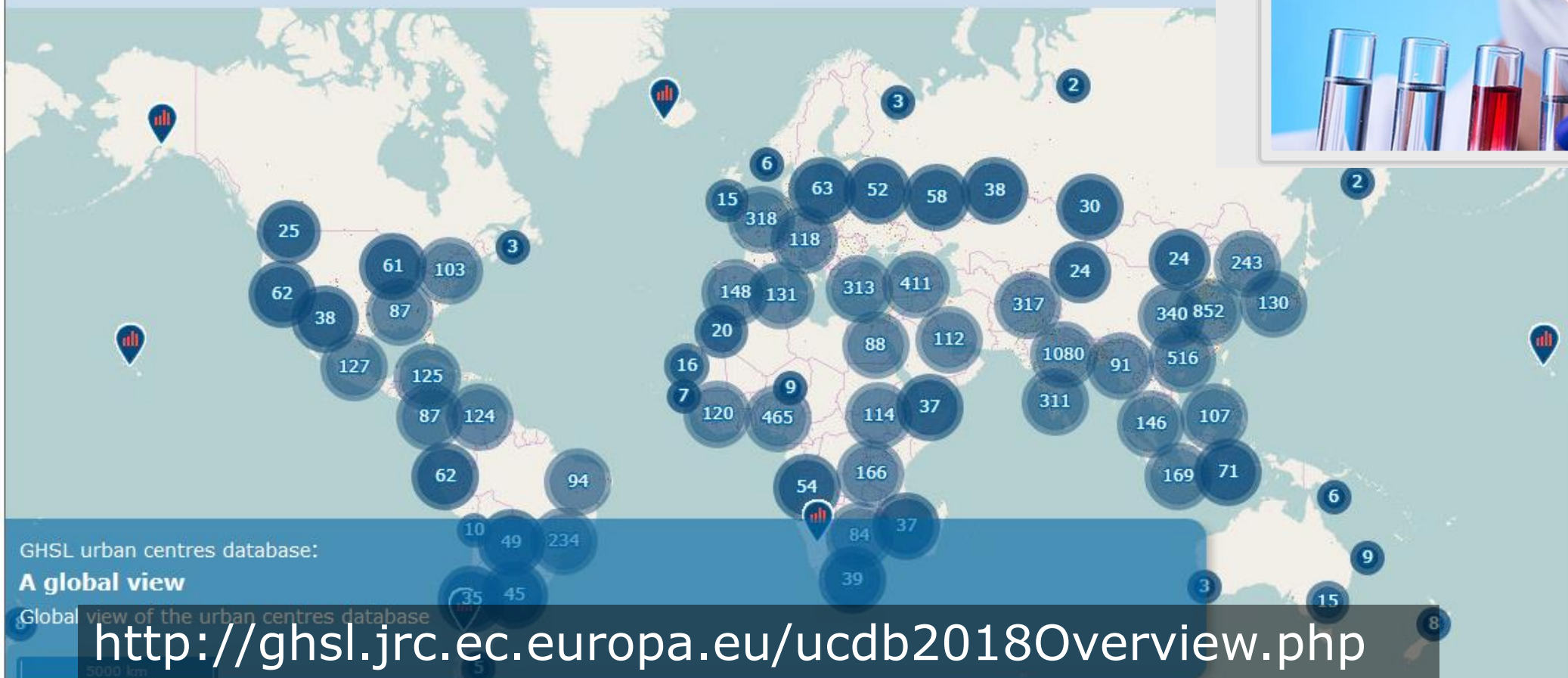


European Commission > EU Science Hub > GHS > Atlas > Urban centres database 2018 overview

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Use the menu below to navigate through the Atlases and their content

Urban Centre Databa... Overview

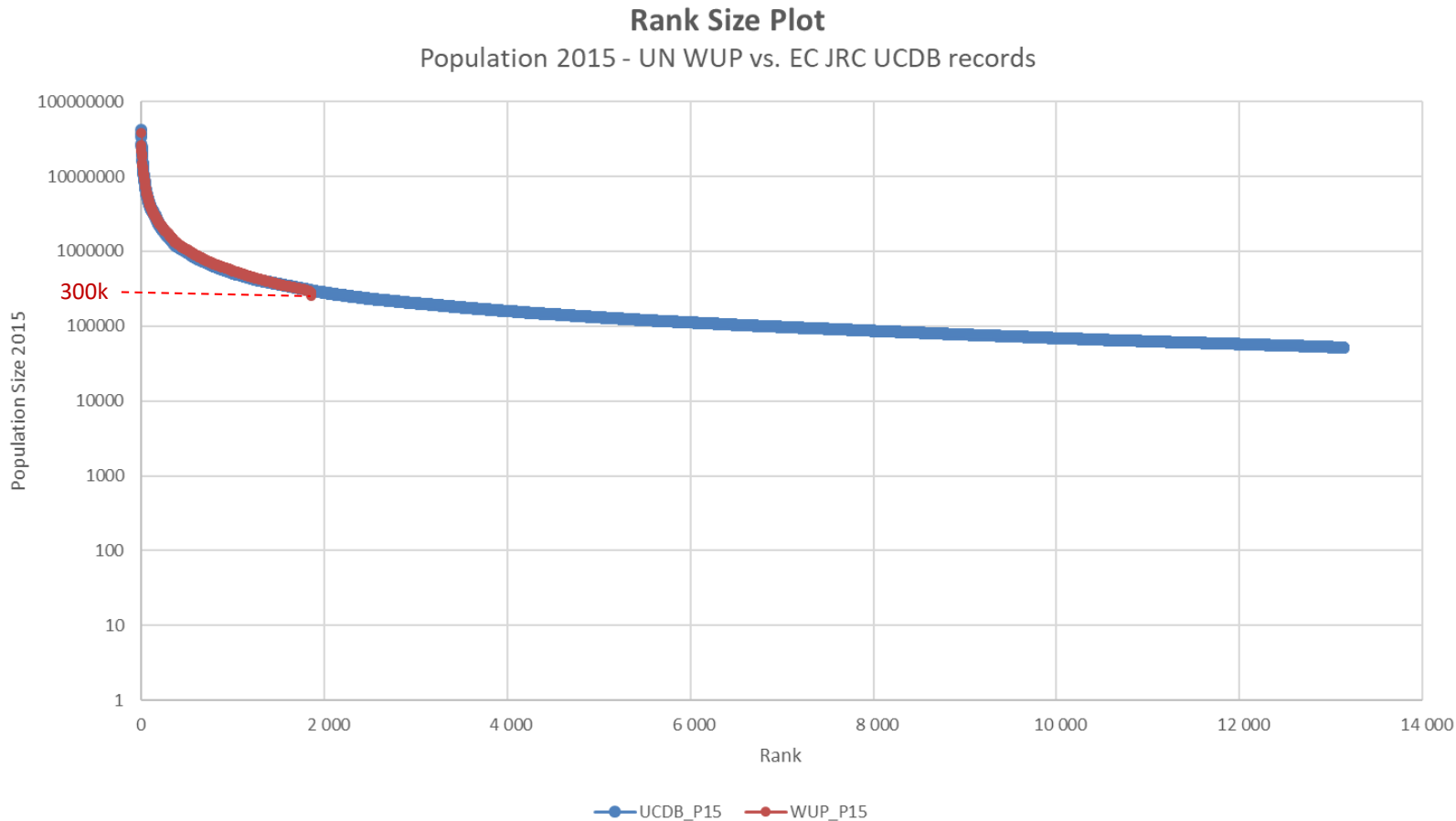


<http://ghsl.jrc.ec.europa.eu/ucdb2018Overview.php>

10,000+ Urban Centres



Completeness - UCDB vs UN WUP



- Same story (established/UN-accepted notion of city) until the 300K size
- Taking over from the 300K to the 50K range
- ~5 times more records than UN WUP

GHSL UCDB: organized info per city

Attributes for the urban centre

Urban Centre name: Bologna [ITA]

Get a link to share this visualisation:

[Link to share](#)

[Data for this Urban Centre](#) (MS Excel format)

Characteristics

Geography

Socio-Economic

Environment

Exposure and hazard

SDG

Name of the Urban Centre: Bologna (ITA)

Resident population in 2015: 421 342 inhabitants

Surface in 2015 (km²): 96

Average Population Density in 2015 (inhabitants/km²): 4 389

Geographical coordinates (centroid): Lat.: 44.4937, Lon.: 11.3290

Country: Italy

Number of countries crossed: 1 country

Countries crossed (ISO codes): ITA

UN region: Europe

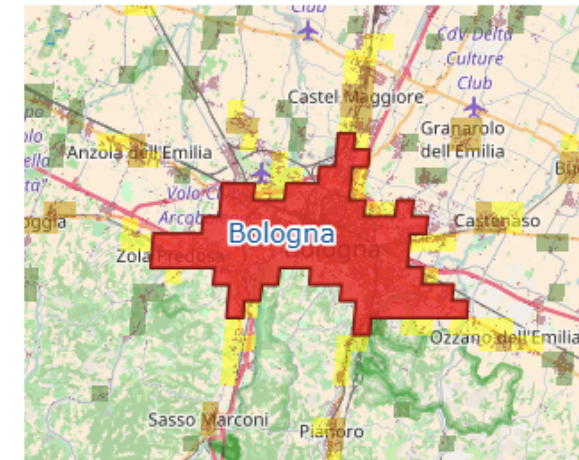
UN subregion: Southern Europe

UN income class: High-income Countries (HIC)

UN development class: More Developed Regions (MDR)

UN region, subregion, income class and development class are extracted from UN World Urbanization Prospects (WUP) 2018

Map of Bologna [ITA]



GHSL UCDB: organized info per city

Urban Centre name: Bologna [ITA]

Get a link to share this visualisation:

[Link to share](#)

[Data for this Urban Centre](#) (MS Excel format)

Characteristics

Geography

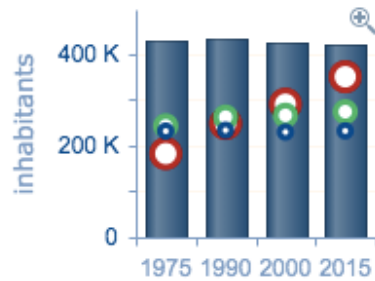
Socio-Economic

Environment

Exposure and hazard

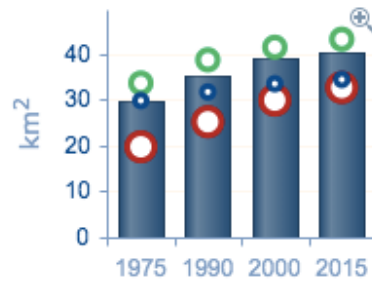
SDG

Population



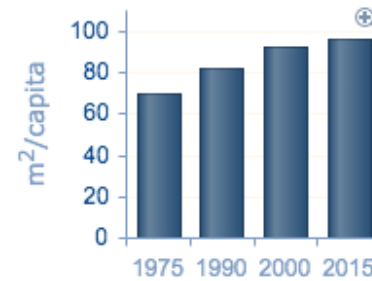
Total population

Built-up area (sq km)



Total built-up area

Built-up/capita (sq m)



Built-up area (sq m) per capita

Averages for the attribute

- Global
- Regional (Europe)
- National

GHSL UCDB: organized info per city

Urban Centre name: **Bologna [ITA]**

Get a link to share this visualisation:

[Link to share](#)

[Data for this Urban Centre](#) (MS Excel format)

Characteristics

Geography

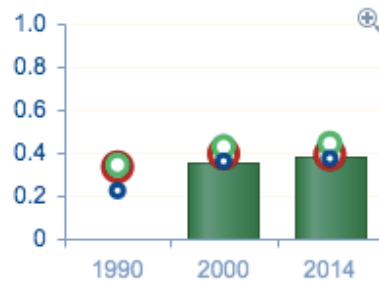
Socio-Economic

Environment

Exposure and hazard

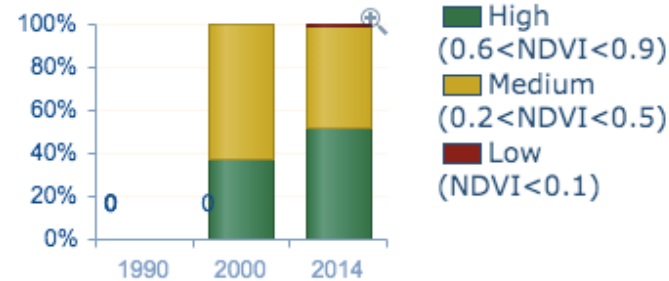
SDG

NDVI



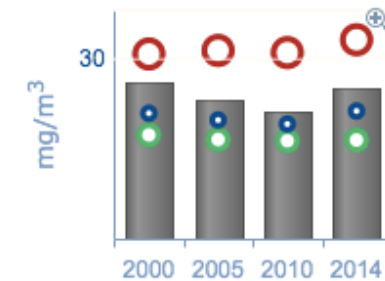
Amount of healthy vegetation in the city centre as estimated by the Normalized Difference Vegetation Index (NDVI)
Unitless value in the range from 0 to 1

Vegetated Surfaces



Share of surface by class of Normalized Difference Vegetation Index (NDVI)

PM 2.5 Concentration



Fine Particulate Matter_{2.5} concentration (mg/m³)

Averages for the attribute

- Global
- Regional (Europe)
- National

GHSL UCDB: organized info per city

Urban Centre name: **Bologna [ITA]**

Get a link to share this visualisation:

[Link to share](#)

[Data for this Urban Centre](#) (MS Excel format)

Characteristics

Geography

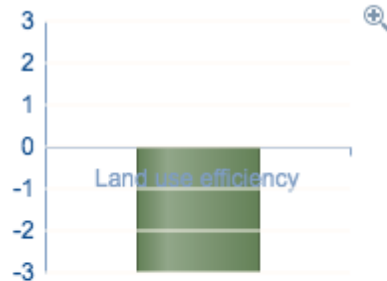
Socio-Economic

Environment

Exposure and hazard

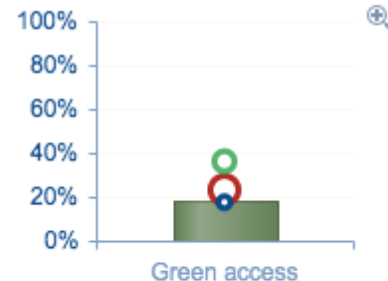
SDG

Land use efficiency



Ratio of land consumption growth rate to population growth rate (SDG11.3.1) between 1990 and 2015

Access to green areas



Percentage of population living in dense green areas (2014)

Averages for the attribute

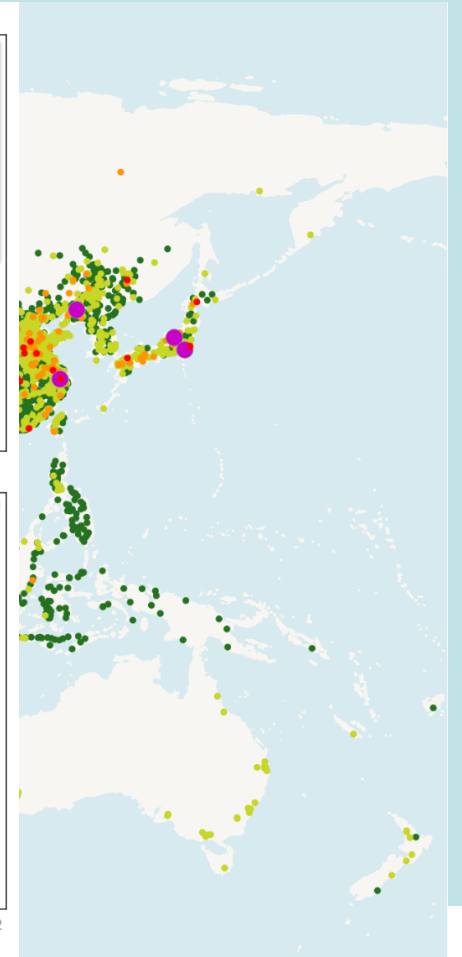
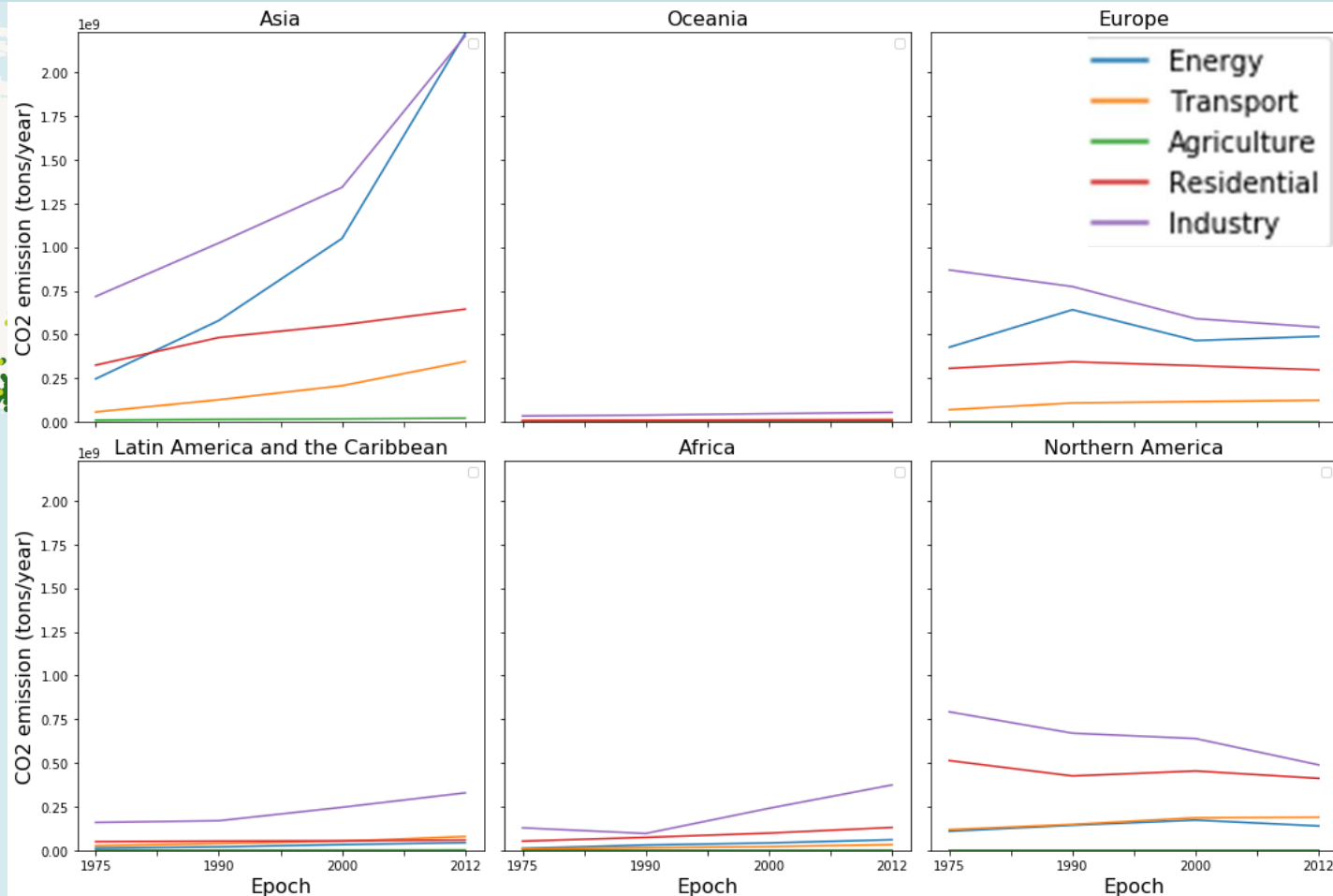
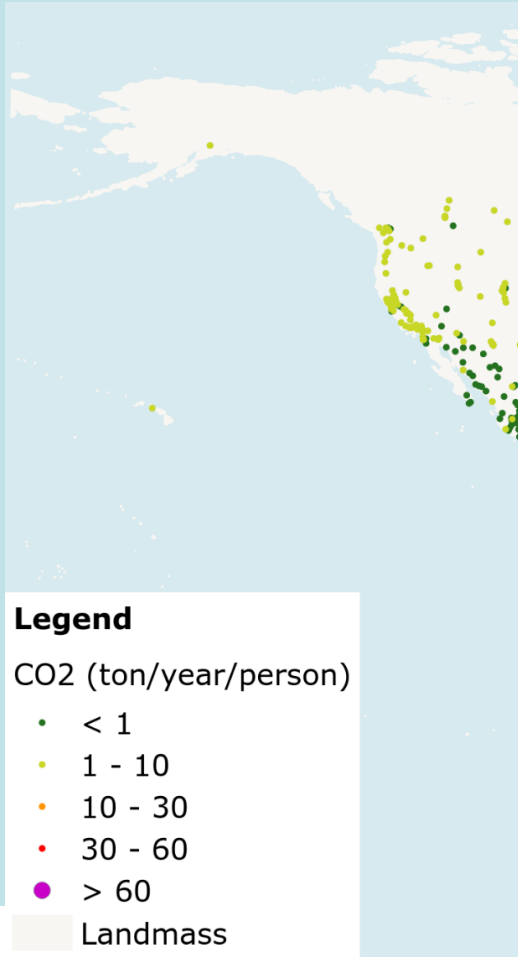
- Global
- Regional (Europe)
- National

Averages for the attribute

CO2 emissions @UCDB



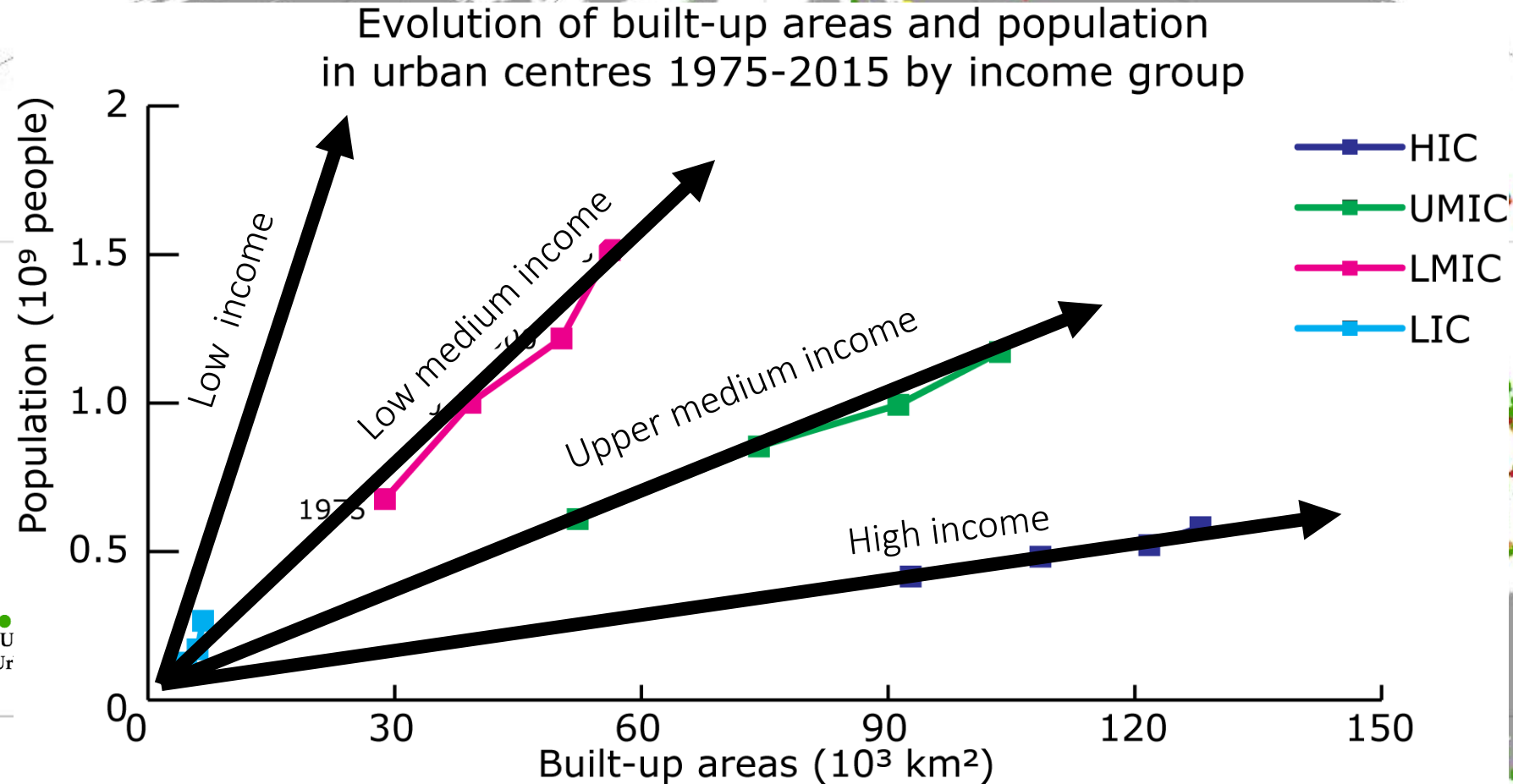
GHS-UCDB



Urban centres classified by annual CO2 emission per inhabitant (ton/year/person) in 2012

Assessing development trajectories

Societal variables trends (1975-2015)



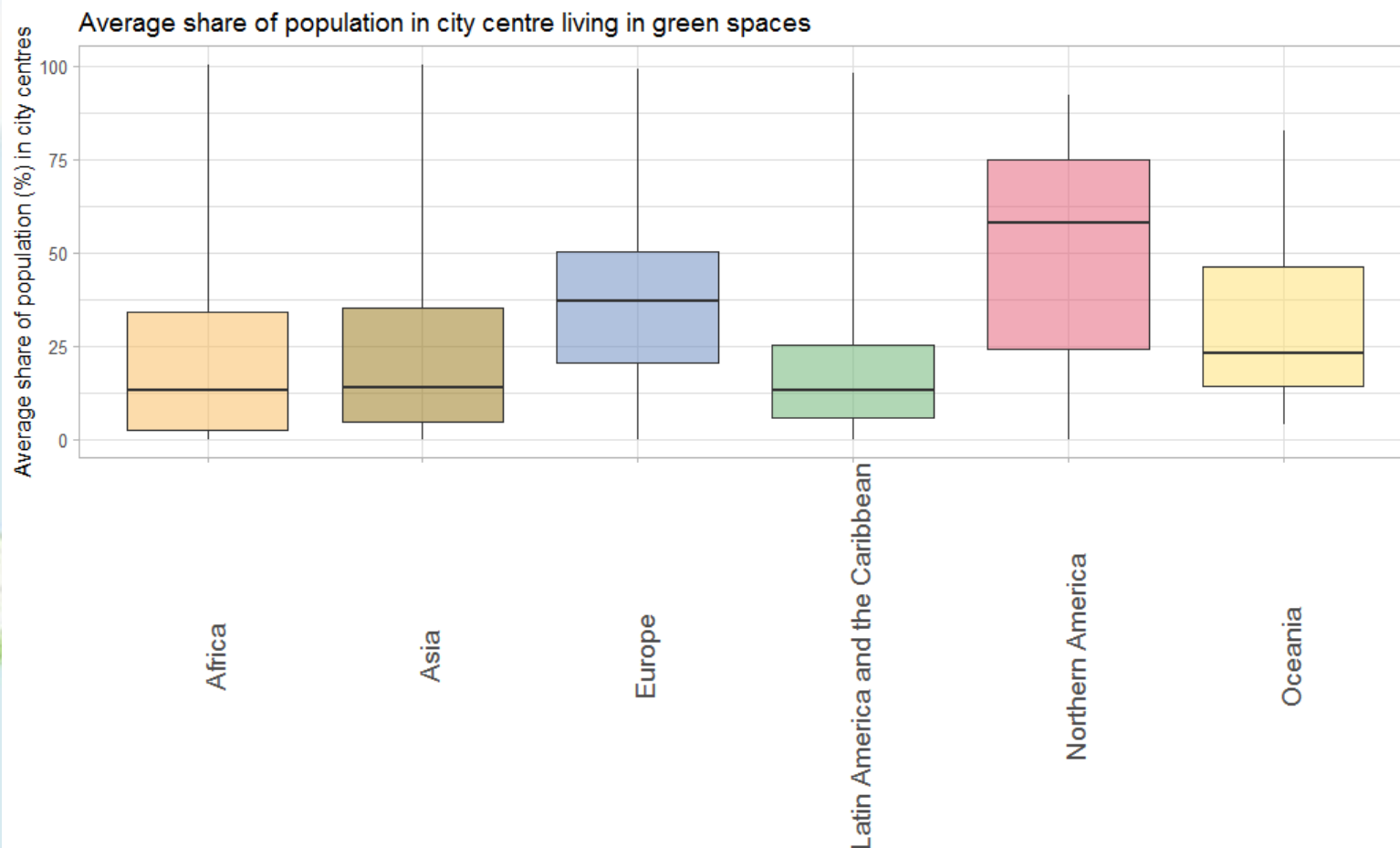
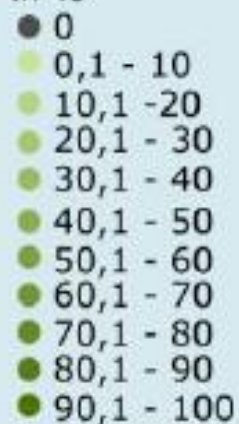
Access to green (SDG 11.7.1) @UCDB



GHS-UCDB

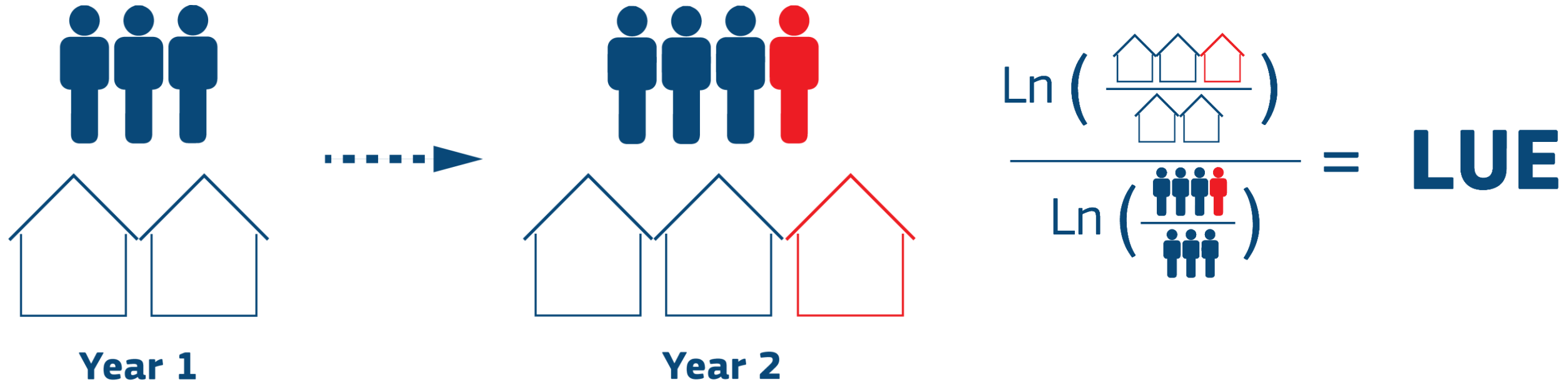
Share of 2015 population with access to green areas

Urban centre population
in 2015 in areas of high green
in %



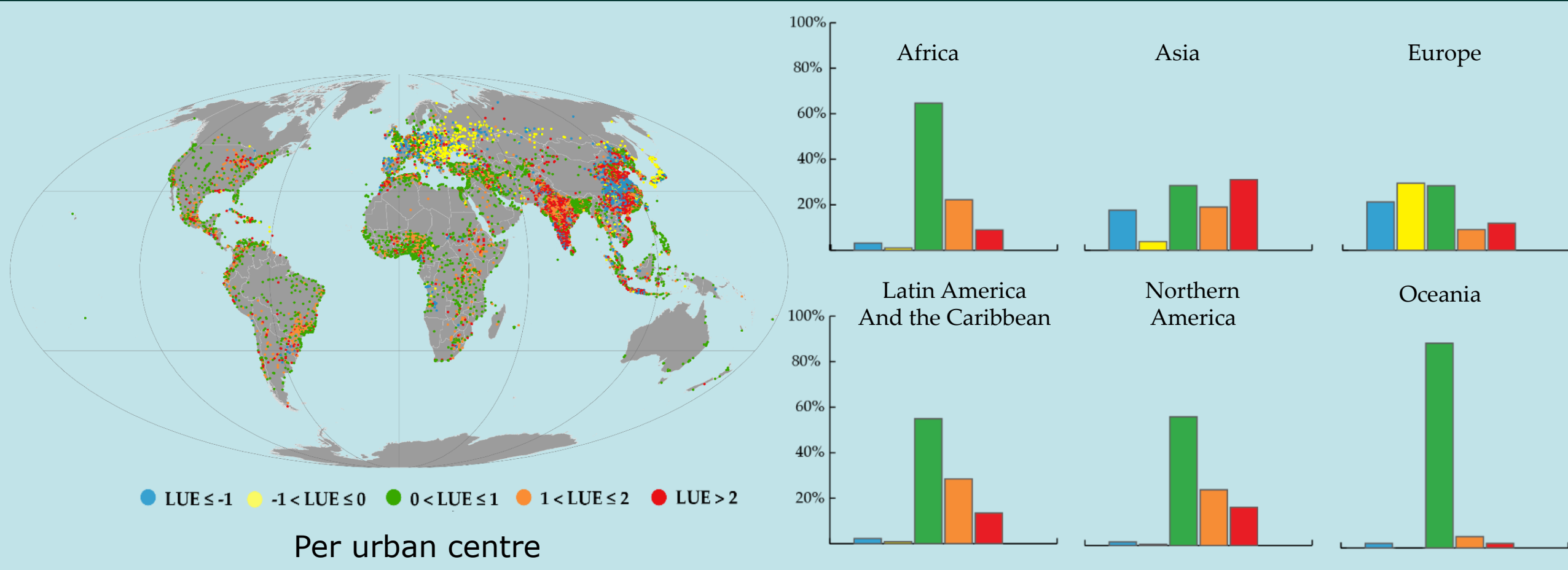
Corbane, C., Martino, P., Panagiotis, P., Aneta, F.J., Michele, M., Sergio, F., Marcello, S., Daniele, E., Gustavo, N., Thomas, K., 2018. The grey-green divide: multi-temporal analysis of greenness across 10,000 urban centres derived from the Global Human Settlement Layer (GHSL). International Journal of Digital Earth 1–18.

Land Use Efficiency (SDG 11.3.1) @UCDB



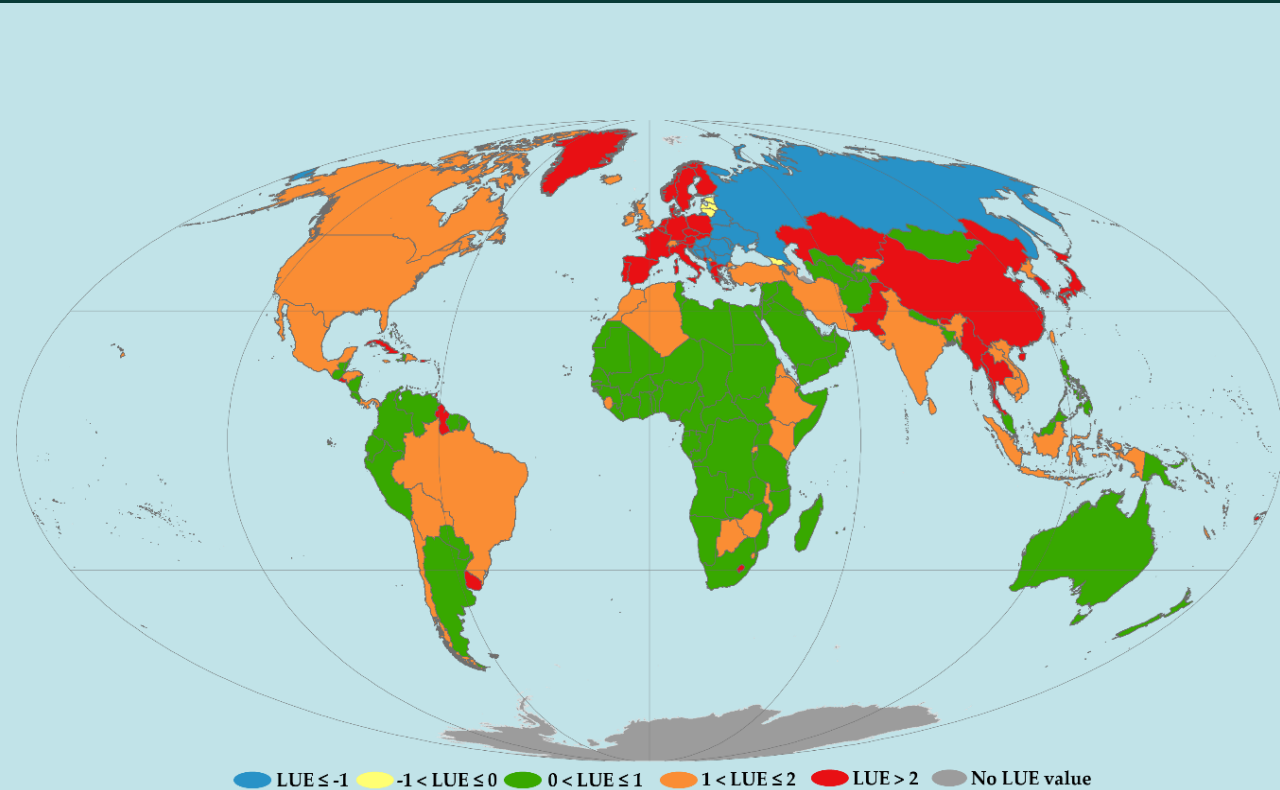
Ratio of land consumption rate to population growth rate
Tier II indicator

Land Use Efficiency (SDG 11.3.1) @UCDB

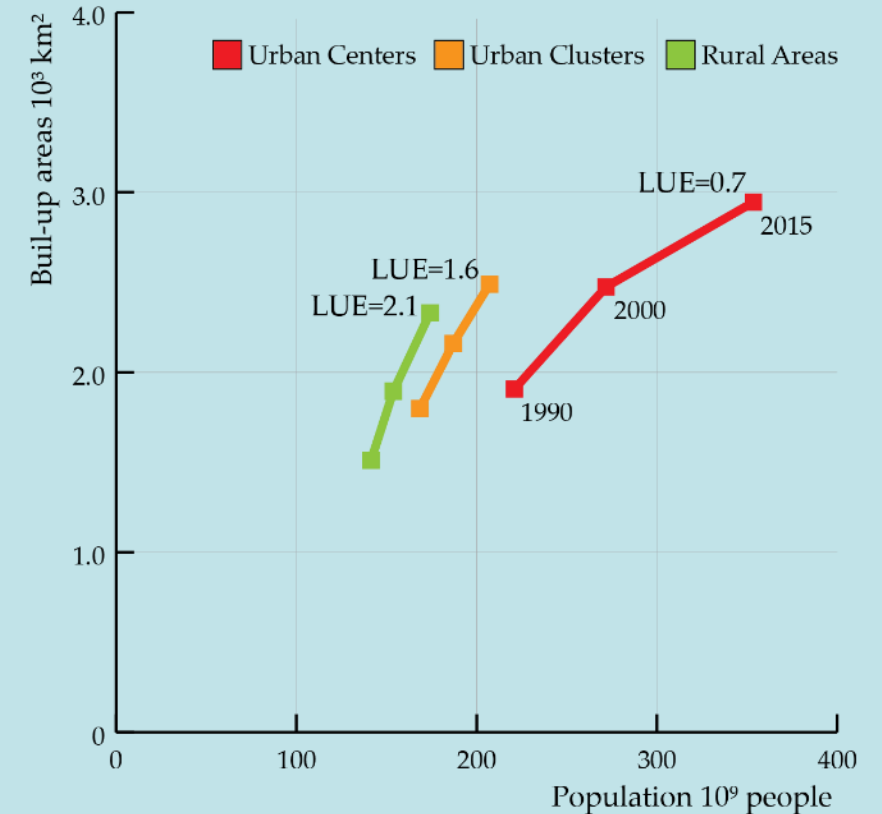


Schiavina, M., Melchiorri, M., Corbane, C., Florczyk, A. J., Freire, S., Pesaresi, M., Kemper, T. Multi-Scale Estimation of Land Use Efficiency (SDG 11.3.1) across 25 Years Using Global Open and Free Data. Sustainability 2019, 11, <https://doi.org/10.3390/su11205674>

Land Use Efficiency (SDG 11.3.1)

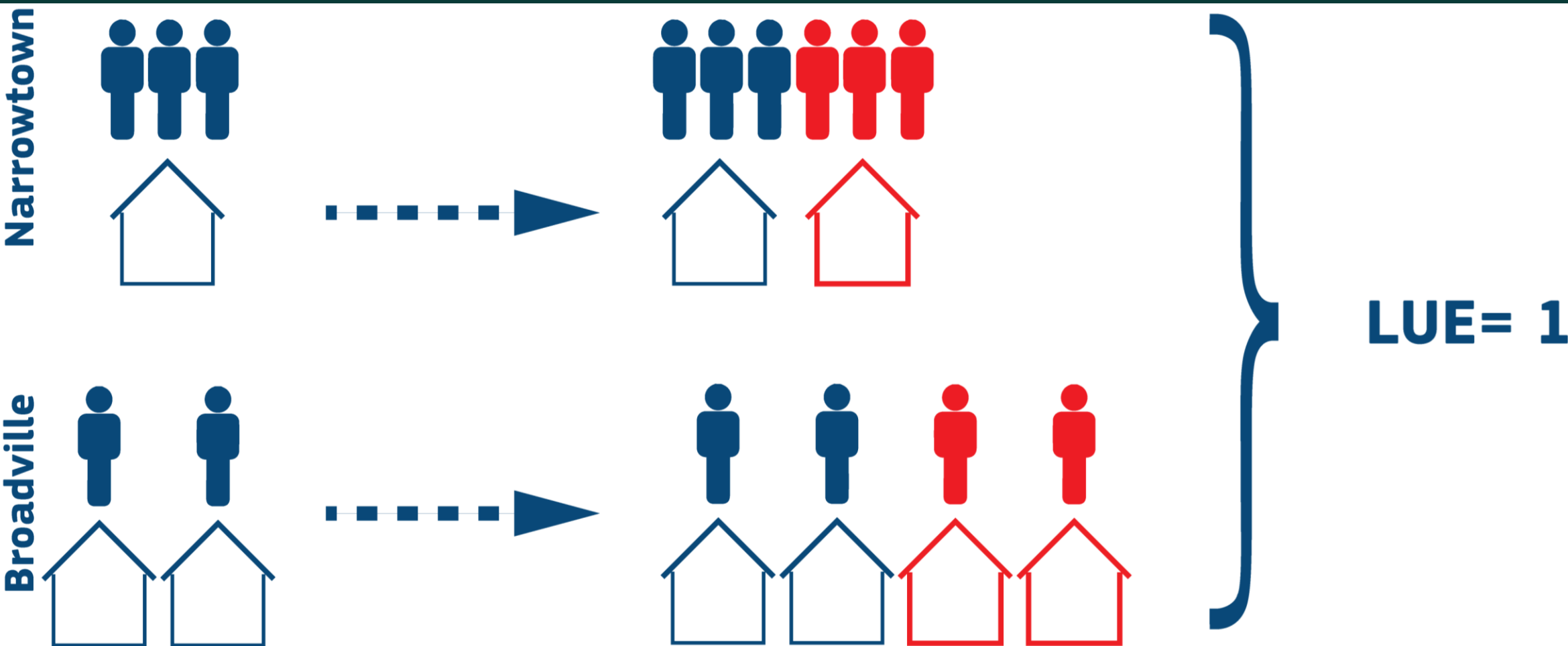


Per country

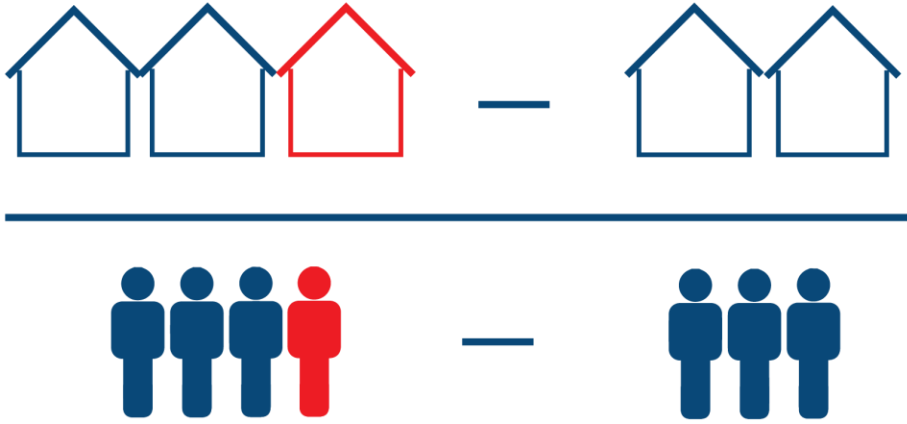


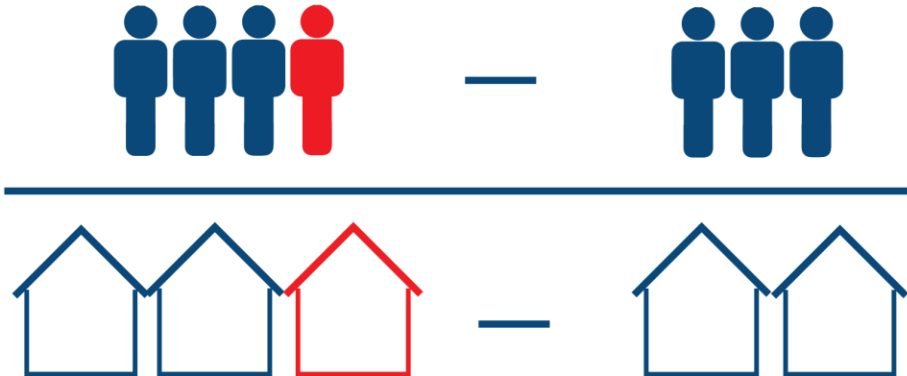
Per settlement type

Comparisons & need for spatially explicit proxy



Spatially explicit proxy metrics

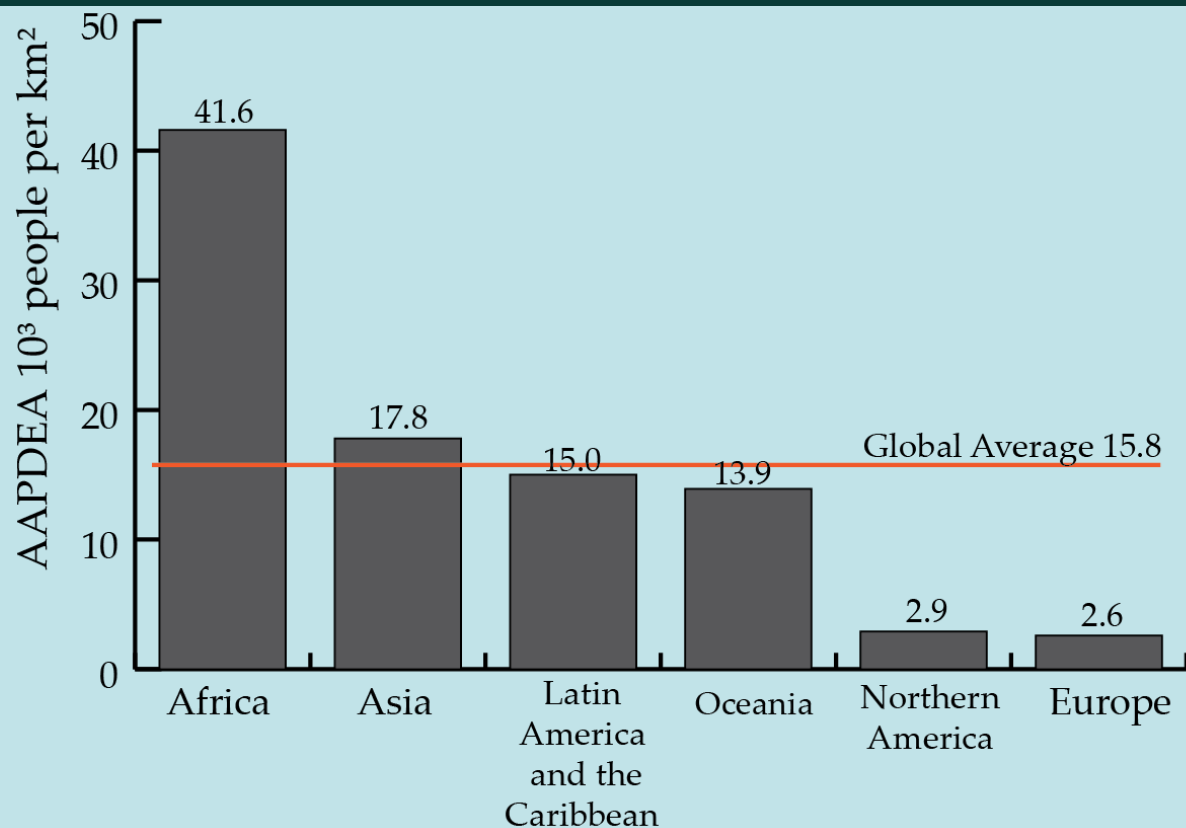
MLCNI =  **in m²per person**

AAPDEA =  **in people per km²**

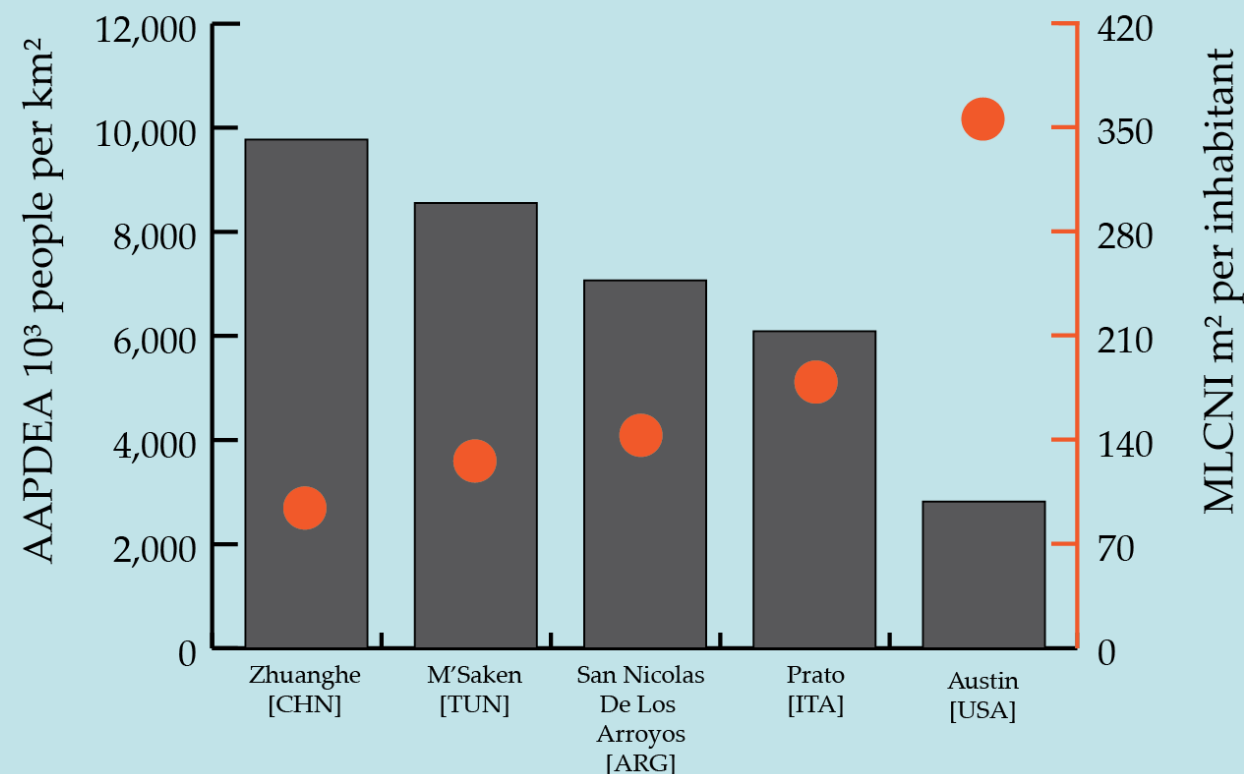
MLCNI = Marginal Land Consumption per new inhabitant (new built area per new inhabitant)

AAPDEA = Abstract Achieved Population Density in new expansion areas (number of people per km² of new built-up area)

AAPDEA and MLCNI examples



Population density in new built-up areas per region of the world



Urban centres comparison (LUE=1)

Melchiorri, M.; Pesaresi, M.; Florczyk, A.J.; Corbane, C.; Kemper, T. Principles and Applications of the Global Human Settlement Layer as Baseline for the Land Use Efficiency Indicator—SDG 11.3.1. ISPRS Int. J. Geo-Inf. 2019, 8, 96.

Schiavina, M., Melchiorri, M., Corbane, C., Florczyk, A. J., Freire, S., Pesaresi, M., Kemper, T. Multi-Scale Estimation of Land Use Efficiency (SDG 11.3.1) across 25 Years Using Global Open and Free Data. Sustainability 2019, 11, <https://doi.org/10.3390/su11205674>



LUE estimation framework with GHSL



Integrated assessment of LCR
Sentinel 1, Sentinel 2, Landsat



Delineation of areas of interest
Urban centres, urban clusters



Run the LUE estimation with a
Urban extent, built-up area grid, population grid



The GHSL web platform

- Information (reports, articles, atlases)
- Visualization
- Download (data, tools)
- Feedback



The screenshot shows the homepage of the GHSL (Global Human Settlement Layer) web platform. At the top, there is a header with the European Commission logo and the text "EUROPEAN COMMISSION Global Human Settlement". Below this is a navigation bar with links: Home, About, Copernicus, Documents, Atlases, Global Definition, Data, Tools, Visualisation, and News. The main content area features the title "GHSL - Global Human Settlement Layer" and a subtitle "A new open and free tool for assessing the human presence on the planet". A list of bullet points describes the platform's capabilities and its support by the Joint Research Centre (JRC) and the DG for Regional Development (DG REGIO). To the right of the text is a gold medal icon with the number 1 and the text "Geospatial World Excellence Award". At the bottom, there is a news section with the date "07/09/2017" and the title "Human Planet Forum 2017", followed by a paragraph of text.

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European Commission

EUROPEAN COMMISSION
Global Human Settlement

European Commission > EU Science Hub > GHSL

Home About Copernicus Documents Atlases Global Definition Data Tools Visualisation News

GHSL - Global Human Settlement Layer

A new open and free tool for assessing the human presence on the planet

- Produces new global spatial information, evidence-based analytics and knowledge describing the human presence on the planet
- Operates in an open and free data and methods access policy (open input, open method, open output)
- Supported by the Joint Research Centre (JRC) and the DG for Regional Development (DG REGIO) of the European Commission, together with the international partnership [GEO Human Planet Initiative](#)

Geospatial World Excellence Award

07/09/2017 **Human Planet Forum 2017** - The 2017 Human Planet Forum will take place in Enschede, Netherlands, 13-15 September 2017. The forum is open to established and potential partners interested to engage with the GEO Human Planet Initiative.

<http://ghsl.jrc.ec.europa.eu>



Thanks

Any questions?

You can find me

marcello.schiavina@ec.europa.eu

Joint Research Centre (JRC)

Directorate E. Space, Security & Migration

Disaster Risk Management Unit

<http://ghsl.jrc.ec.europa.eu>