# Global Urban Data Initiative

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esa

## ISTANBUL
## April 22, 11-12.30 pm

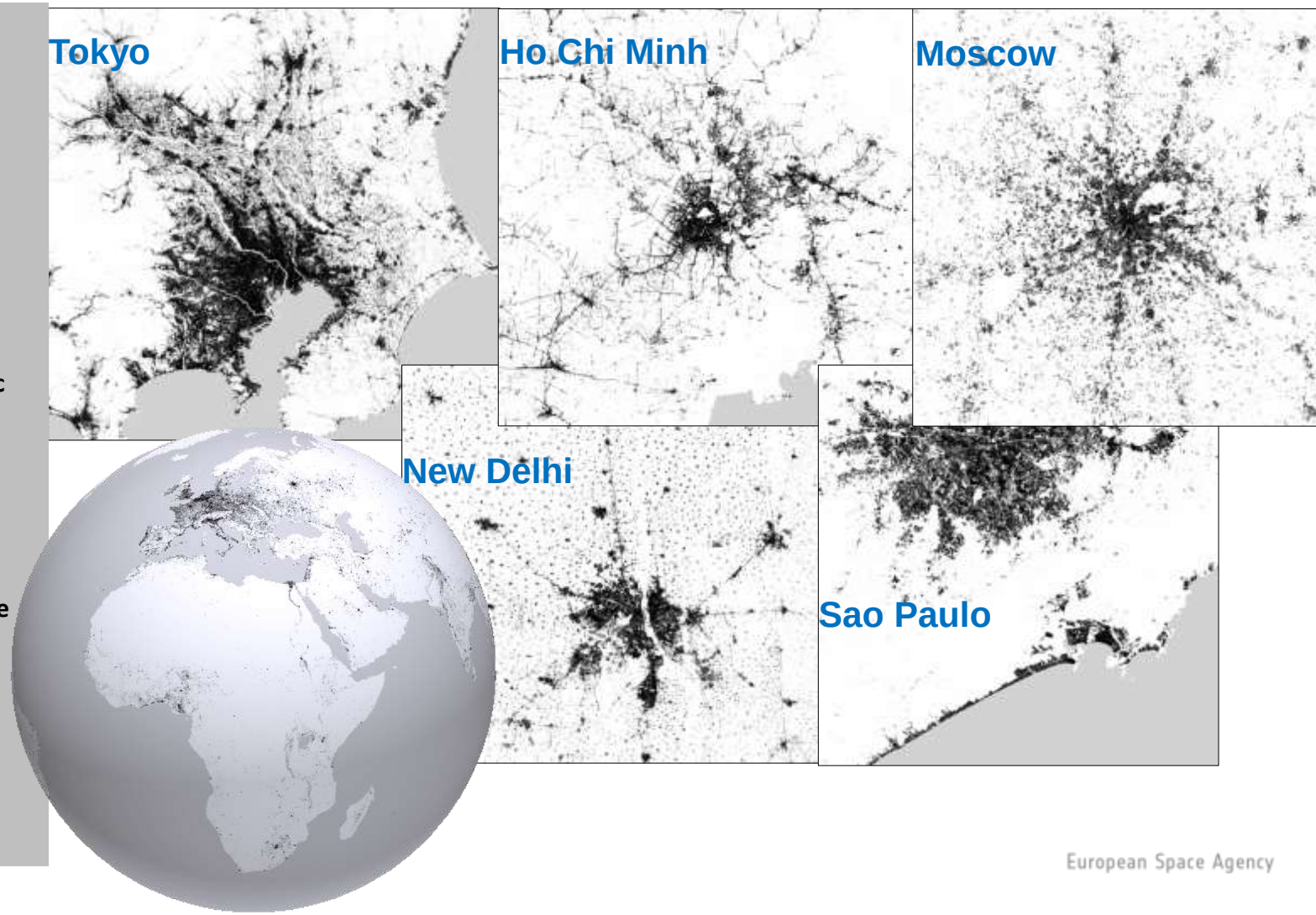
**Global Urban Data Initiative**
***Global Urban and DRM Unit***

**LEARN ABOUT:**

- Data Access through PUMA Portal and ESA Urban Thematic Exploitation Platform (TEP)
- Urban mapping technical specifications

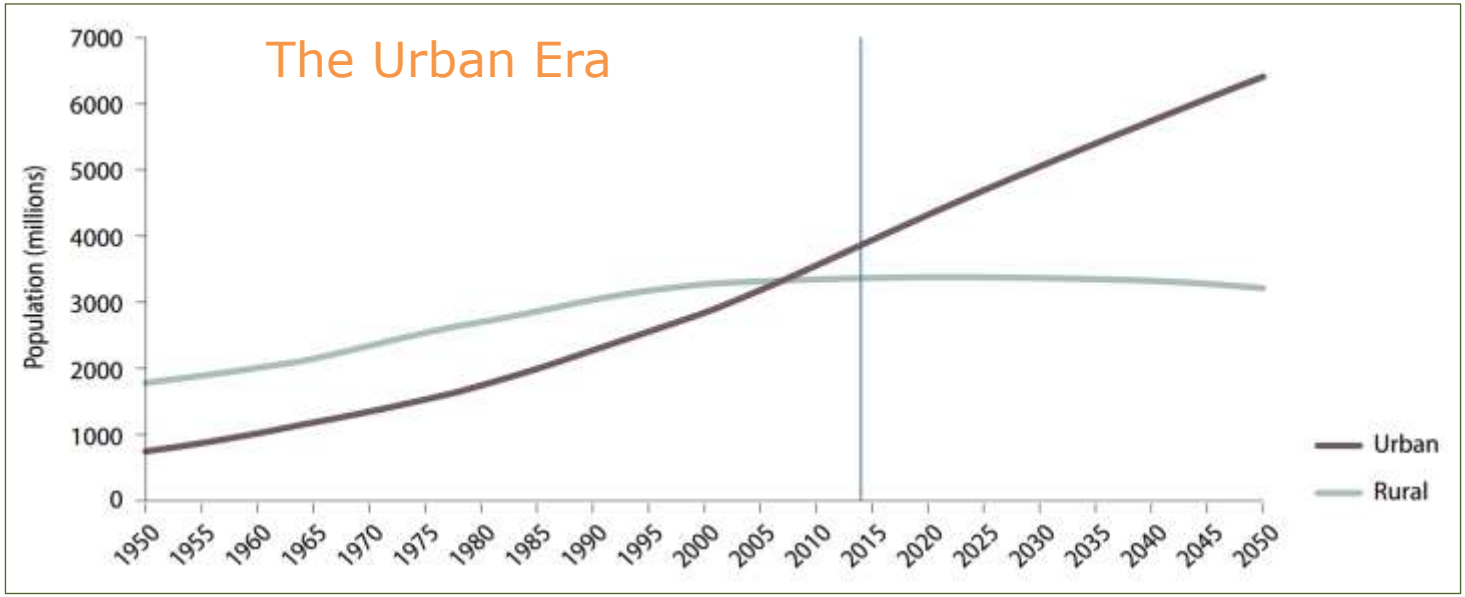
**DISCUSS** your data needs

**DISCOVER** possibilities to collaborate with technical partners and data developers




European Space Agency

# Urbanization and sustainable development




Source: United Nations Department of Economic and Social Affairs/Population Division 5. World Urbanization Prospects The 2014 Revision.

In future, urban areas will account for:

- 90% of population growth,
- 80% of increased prosperity ,
- 60% of energy consumption.

# Measuring Urban Growth

- At present there is no global source of information to consistently and reliably monitor urban expansion and population change
  - Wide variety of inconsistent methods in the past resulted in estimations of urban land cover between 0.2 to 3% of land mass
  - Existing sources of data are not comparable because countries define urban extents differently
  - Redefinition of areas from rural to urban frequently lacks actual change in  land use and population density

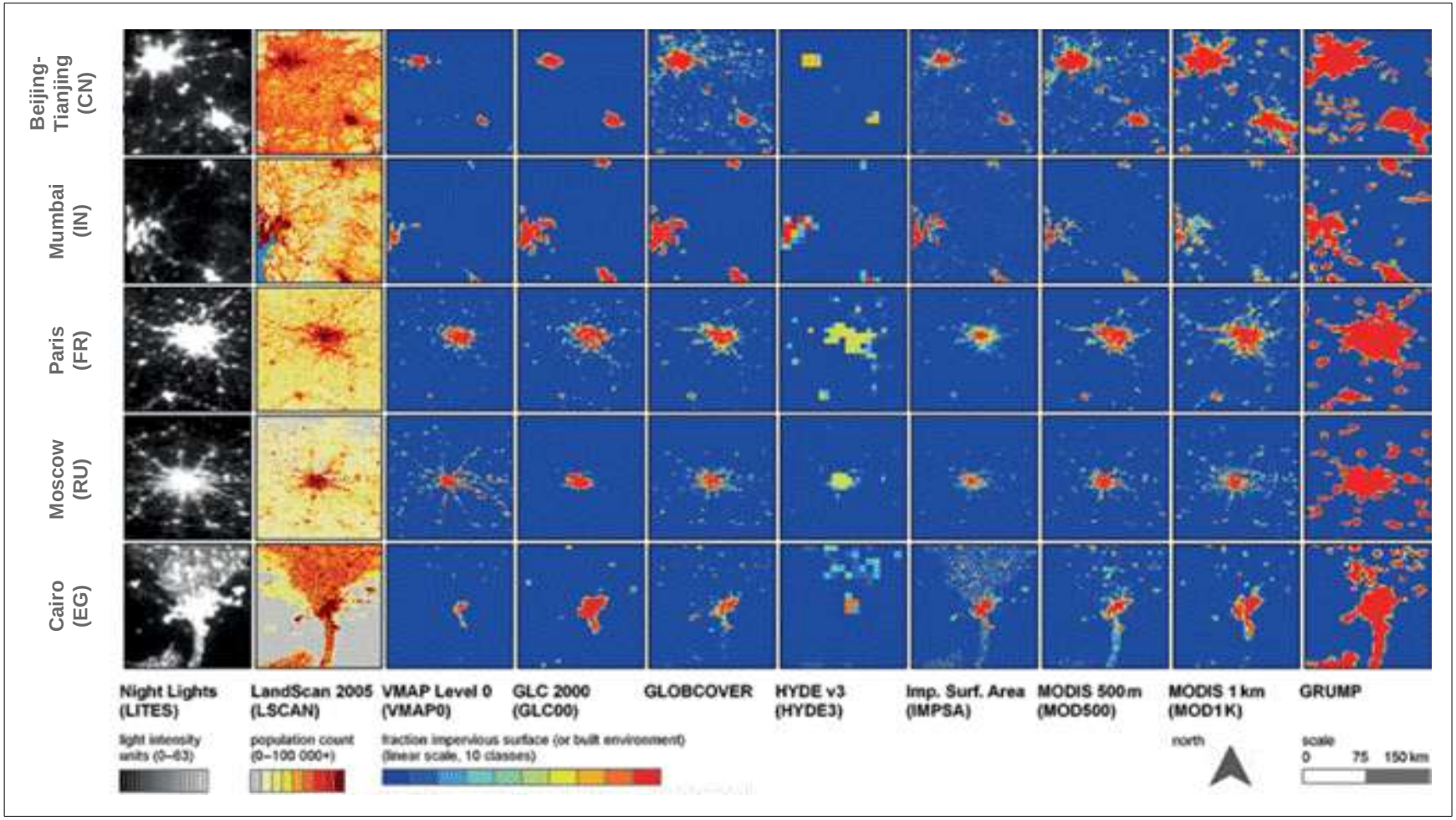
# Measuring Urban Growth

## Human Settlements layers
## Ongoing efforts worldwide indicate a global demand

- Global Rural-Urban Mapping Project
  - Nightlights and ~1km resolution – Lower resolution
  - 1990, 1995, 2000
  - Sample of cities
- Global Urban Expansion Atlas/"Solly Angel" (200 cities, 1990, 2000, 2013)
- European Commission / OECD
  - Europe + some of the OECD countries
- World Bank Regional Urbanization Reviews East Asia using MODIS 500(250m) and South Asia using nightlights
- Global Human settlements Layer (JRC / EC) (currently in process)
- Urban Land C 2000 and Urban Expansion 2000-2010 – University of Wisconsin, Madison
  - Now extended to cover the world at 250 m spatial resolution
- NOAA's Nightlights Data
- ASTER Global Urban Area map, AGURAM
- And others....

# Measuring Urban Growth

## Currently available Global Human Settlements layers



# Measuring Urban Growth

## Currently available global Human Settlements layers

- In the last decade several **Global Human Settlements Layers (GHSL)** have been produced to map human settlements worldwide.

**NASA MODIS 500** (493 m spatial resolution) and **ESA GlobCover 2009** (309 m spatial resolution)

The limited spatial resolution does **NOT** allow a precise characterization of urban settlements, especially in rural and peri-urban areas (characterized by small and scattered villages and towns)

## Key Policy Questions:

- How are cities changing over time?
- How much, and in what proportion of uses, is land being consumed for urban development?
- Where are the areas with the most significant land use change?
- What are the drivers of urban and other land development, and what new infrastructure will be needed to support this development?
- What are the possible effects of natural disasters and climate change, and how much of the population and assets will be affected?

## Key Data Needs:

- Detailed observation and monitoring
- Moving from Observing and Monitoring to the evaluation of the effectiveness of policy options and modeling
  - Ie. urban growth scenarios, extent/proximity of green urban areas, accessibility, urban heat islands, etc.
  - integration of geographic and statistical information into toolsets and models

**Objective: Improved spatial planning based on the high quality and accurate data**

Fundamental needs identified:

- Free or low cost data
- Better *resolution** & *accuracy** of measurements
- *Fast** and *operational** monitoring system to offset the limitations of the existing estimations such as:
  - variability of methodologies and mapping results,
  - their low spatial resolution (250m-2km), and
  - low frequency of updates.

**Resolution:** different urban scales: regional (250m-80m) / city level (30 m/10m/5m)
**Accuracy:** 75-90% , in situ data for validation is key
**Fast:** possibilities of updates every **3-5 years** on the regional level and every **1 year** on the national level
**Operational:** not R&D! based on the validated algorithms (automated) with quarantined long term (20+ years) data availability
**Free or low cost data:** EMODIS (NASA, free), Envisat (ESA, free), ERS (ESA, free), Landsat (NASA, free), Sentinels (ESA, free)

**Resolution:** different urban scales: regional (250m-80m) / city level (30 m/10m/5m)

**Accuracy:** 75-90% , in situ data for validation is key

**Fast:** decadal is a minimum but true need is in possibilities of updates every **3-5 years** on the regional level and every **1 year** on the national level

**Operational:** not R&D! based on the validated algorithms, automated system (cf. fast) with quarantined long term (20+ years) input data availability, ability to integrate different sources of data (EO and non EO)

**Free or low cost data**:

1km-10 m - **Open & Free** (Landsat, Sentinels) **INFORMATION !**

10-2,5m – Low cost, 1$ sq km(high value) (SPOT, RapidEye, DMC, IRS, CBRES, …, …)

<1m – At cost, cost vary (high value) (WorldView, Pleiades, Kompsat, …,…)

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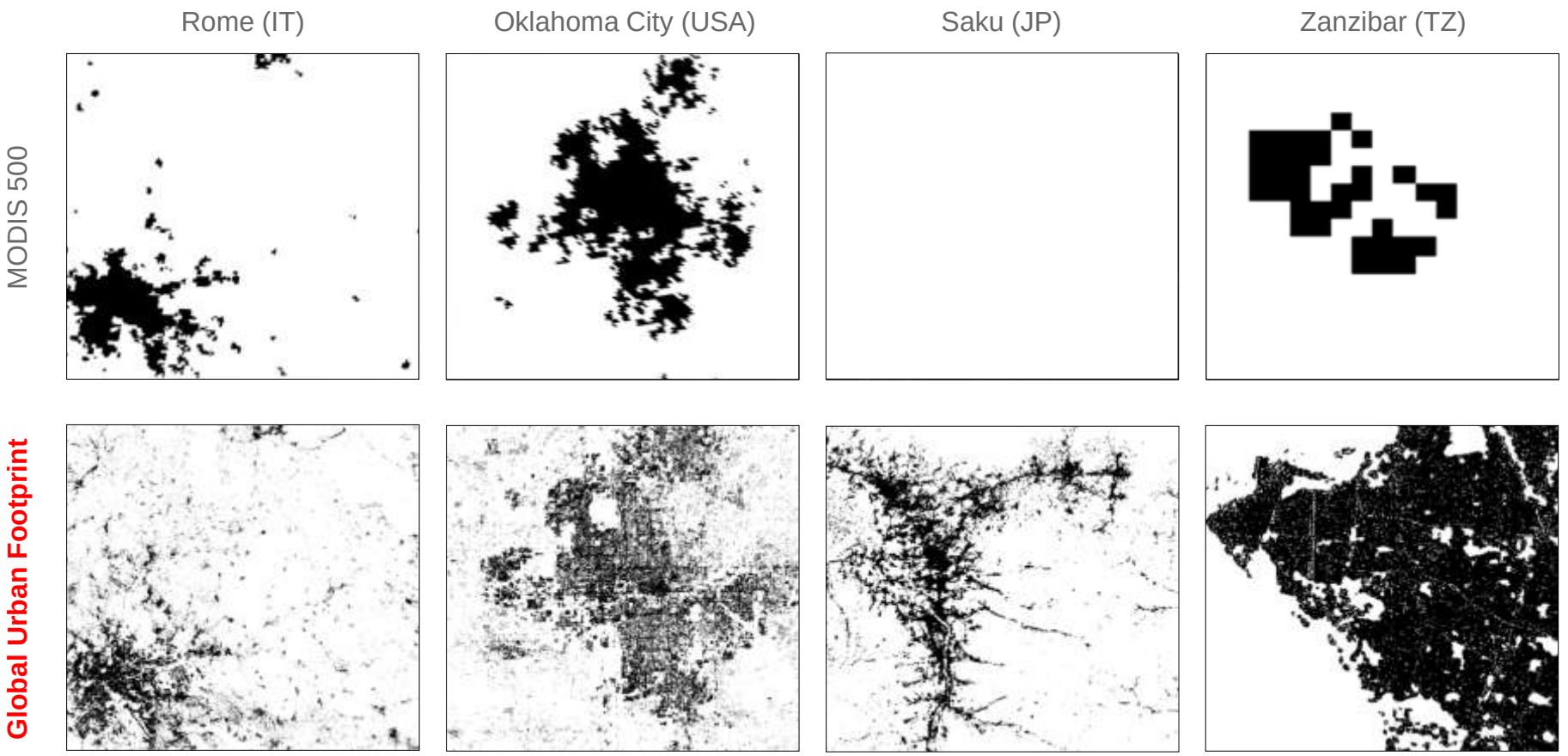
# Monitoring of human settlements required a

# breakthrough

# in observational capacity

# & analytic tools

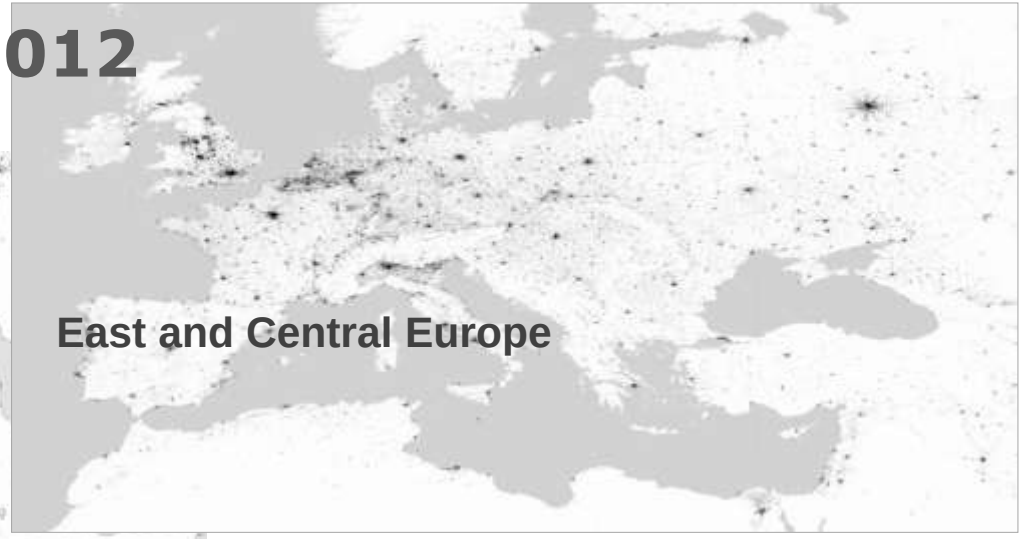
# Global Urban Footprint vs. MODIS 500

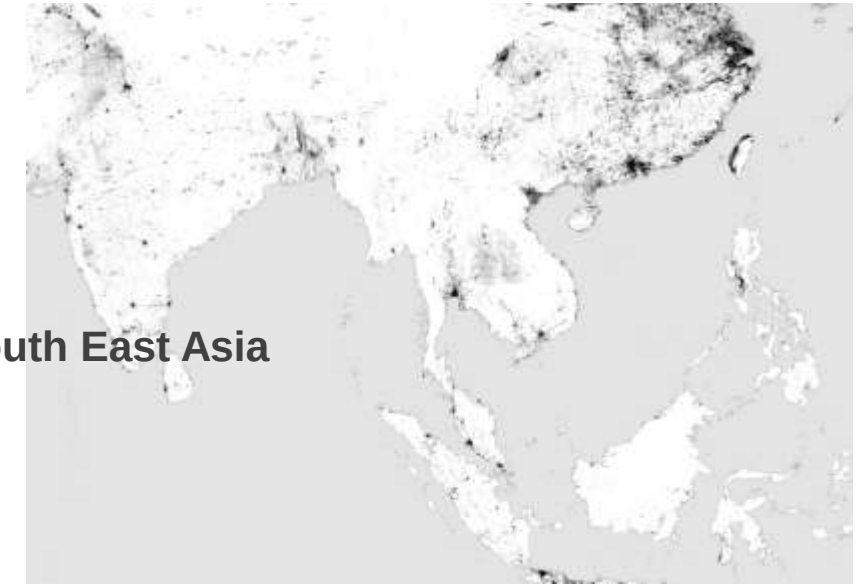



Credit: DLR/German Space Agency Global Urban Footprint, Satellite data: TerraSarX/TandemX mission

# Global Coverage 2011/2012

## Baseline data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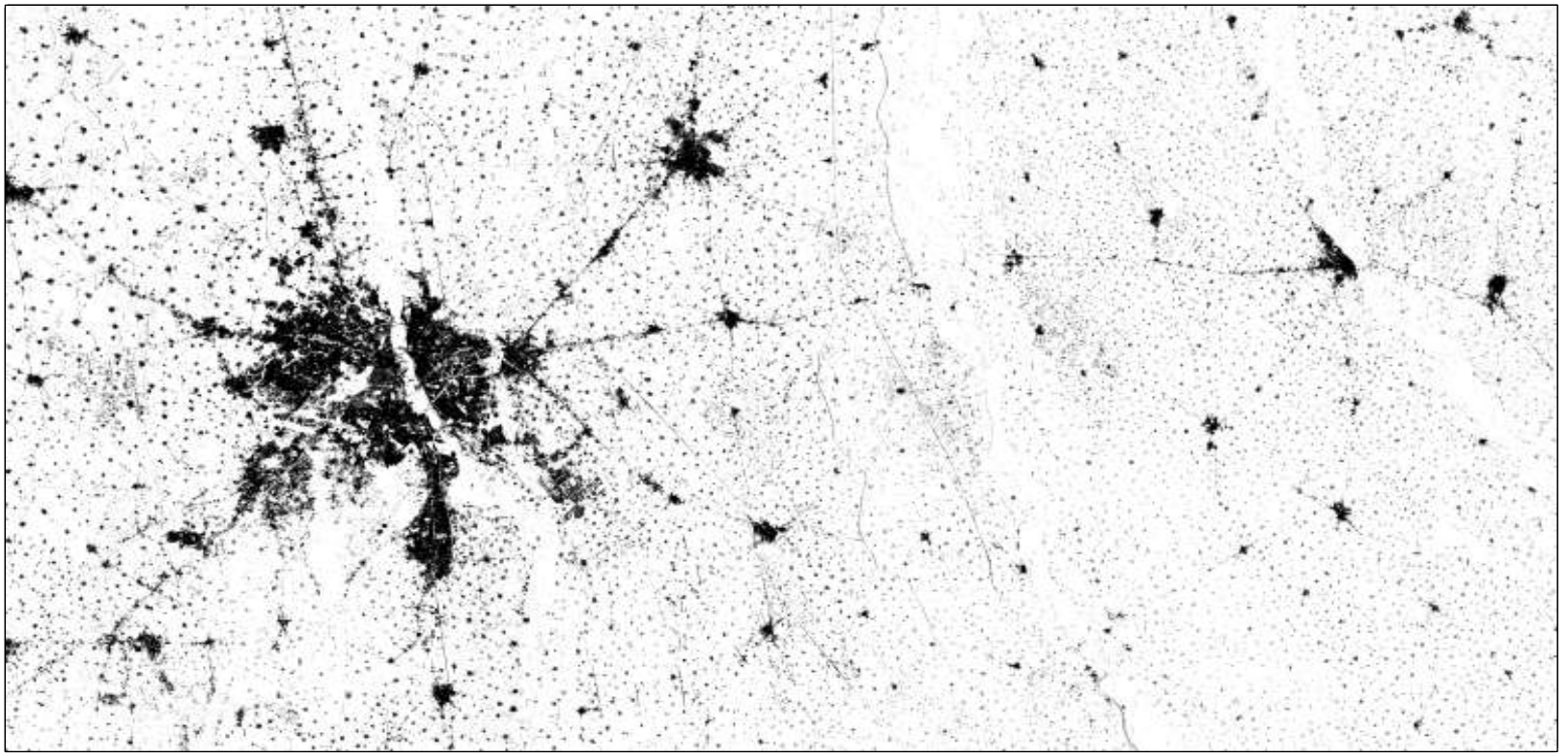
# Global Coverage 2011/2012

## Baseline data – New Delhi, India



original backscattering amplitude  extracted speckle divergence  Global Urban Footprint

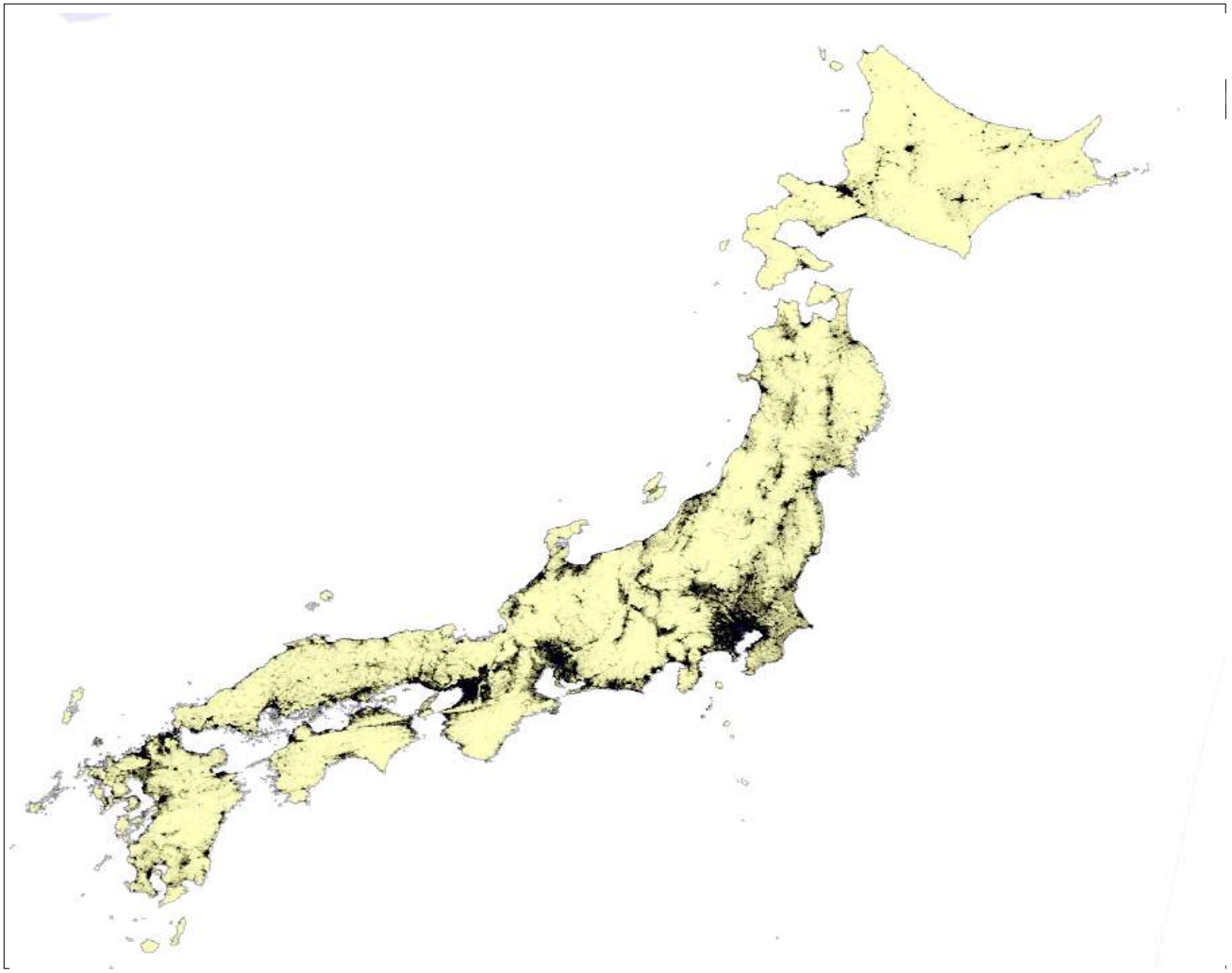
New Delhi Area: **88 images (~90,000 km²)**
Validation (evaluated over 2000 randomly distributed samples): **OA% 86.6, Kappa 0.73**

Credit: DLR/German Space Agency Global Urban Footprint, Satellite data: TerraSarX/TandemX mission

# Global Coverage 2011/2012

## Baseline data – National Demonstrator - Japan

Japan: **~800 images**



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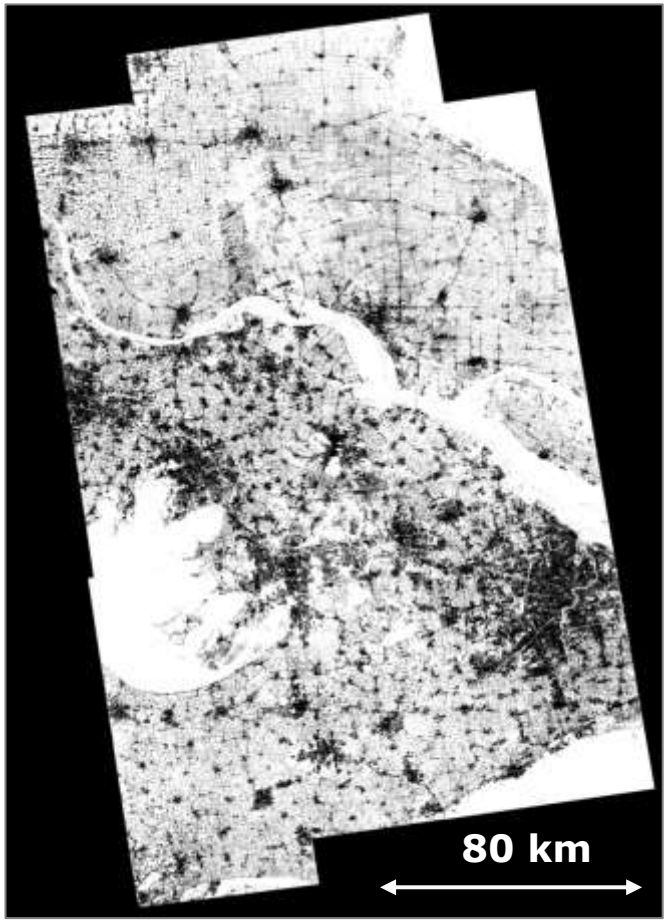


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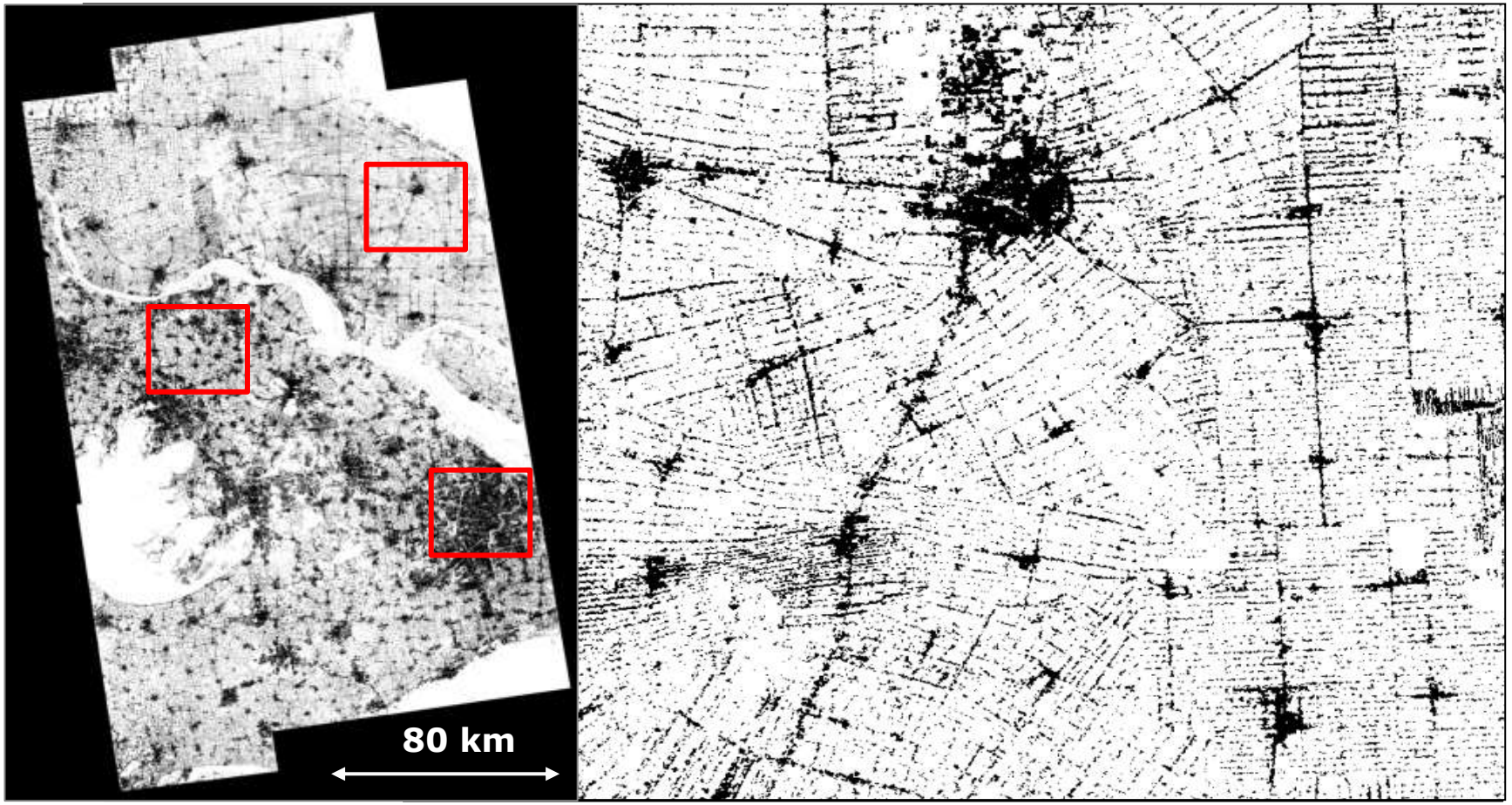



**Urban Footprint**

Credit: DLR/German Space Agency Global Urban Footprint, Satellite data: TerraSarX/TandemX mission

# Global Coverage 2011/2012

## Historical data

**Urban spatio-temporal development** based on historical optical (Landsat MSS, TM and ETM+) and SAR (ERS, ASAR) data + Global Urban Footprint.

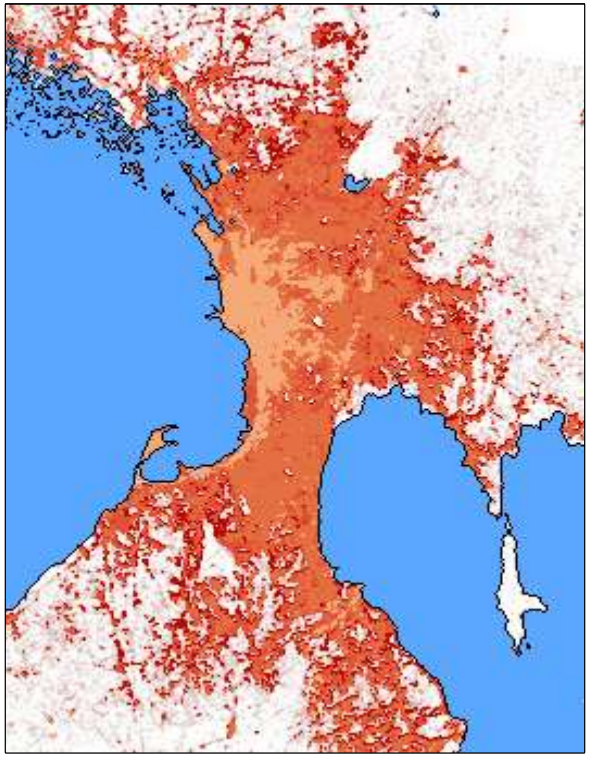
**Manila (Philippines)**

**2010**

**2000**

**1990**

**1975**



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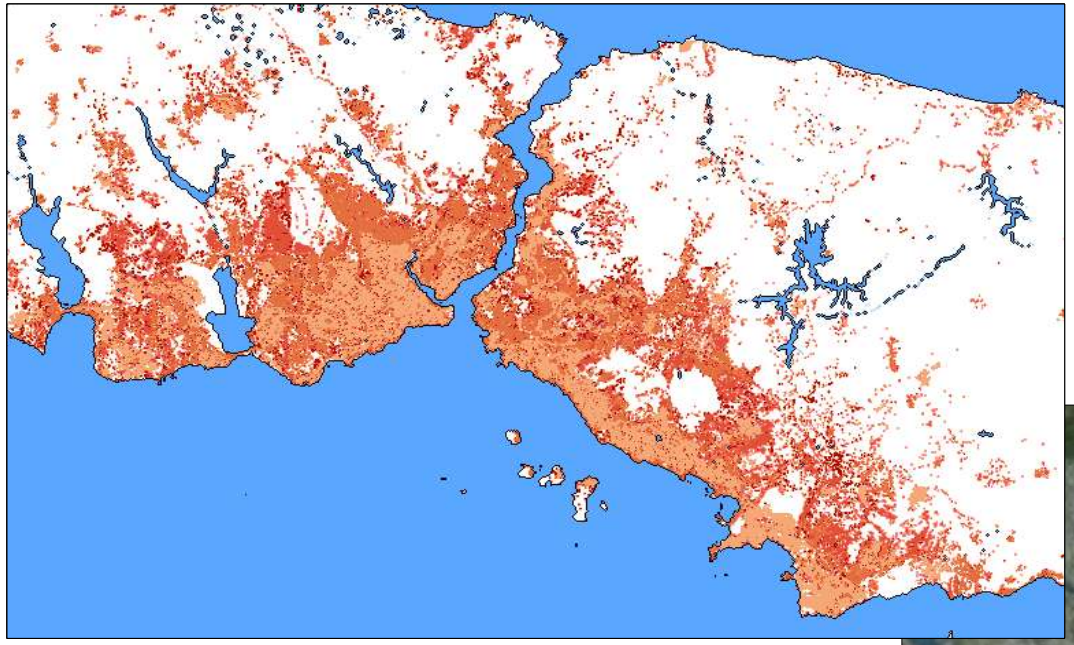
# Global Coverage 2011/2012

## Historical data



1975 1990 2000 2010

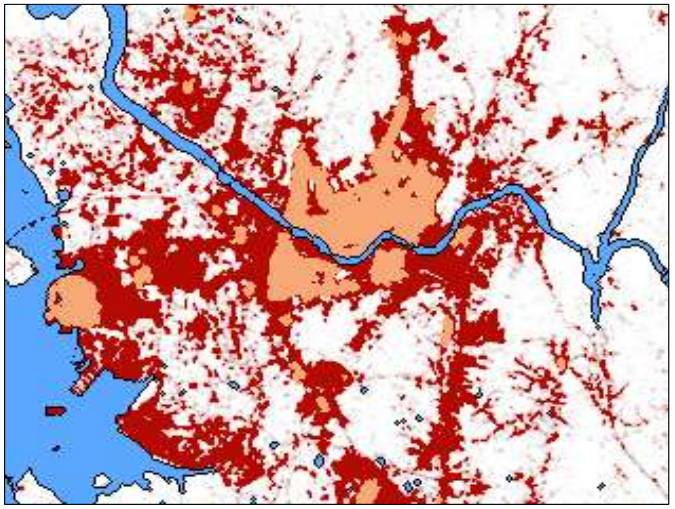
Istanbul (Turkey)

Credit: DLR/German Space Agency, Satellite data: TerraSarX/TandemX mission, Landsat, ERS, Envisat

# Global Coverage 2011/2012

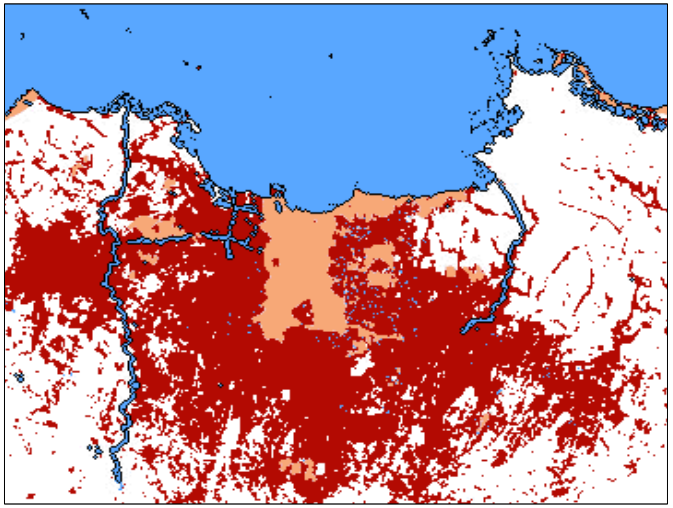
## Historical data

Seoul (South Korea)



1975

2010



Jakarta (Indonesia)

Credit: DLR/German Space Agency, Satellite data: TerraSarX/TandemX mission, Landsat, ERS, Envisat

## 2014 ESA Innovators Project led by DLR

Phase 1 (2015-2016) :

i) **the past urban extent (2002-2003) with ASAR WSM data for East Africa**;

- 75m spatial resolution built-up extent
- It includes entire **Uganda, Rwanda, Burundi and Kenya** in addition to big parts of **Somalia, Ethiopia, South Sudan and Zambia**

ii) **the current urban extent for Addis Ababa, Dar es Salaam and Nairobi from Sentinel-1 IW GRDH data acquired in 2014-2015**.

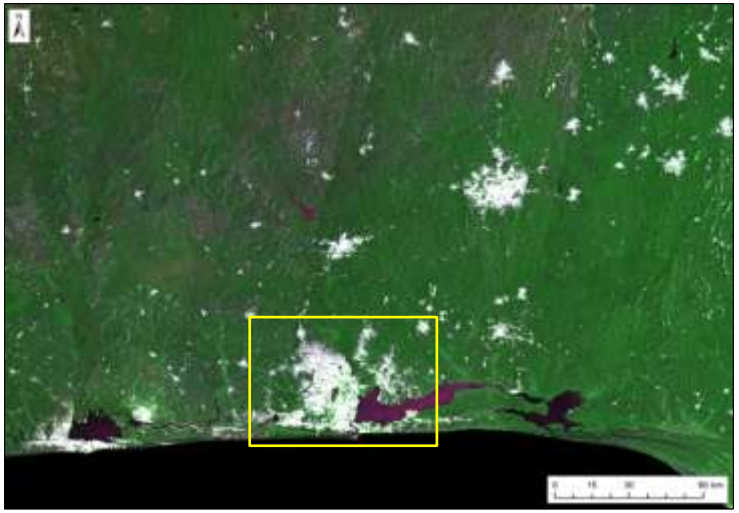
Phase 2 (2016-2017):

i) **the past urban extent (2002-2003) with ASAR WSM data of the remaining part of the African continent**;

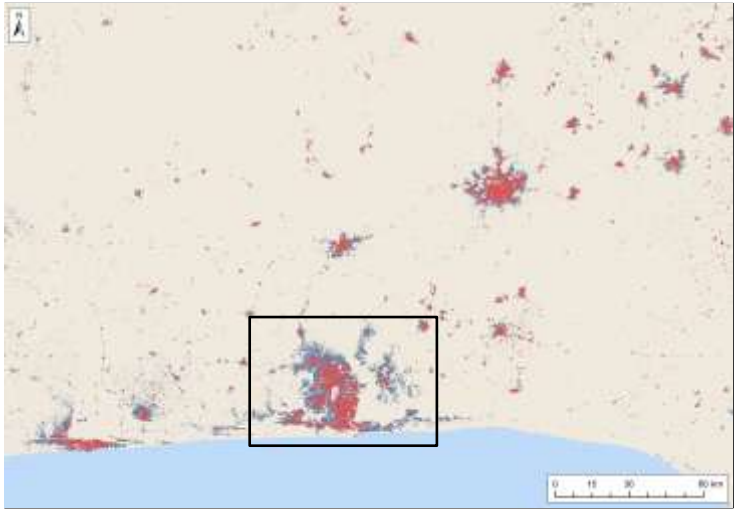
ii) **the current urban extent for Kigali and entire Uganda (including Kampala) from Sentinel-1 IW GRDH data acquired in 2014-2016**

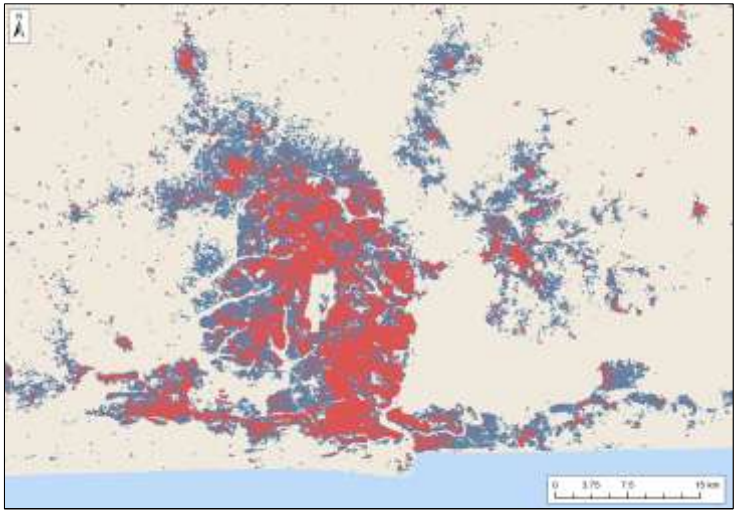
Benin

Nigeria



Lagos





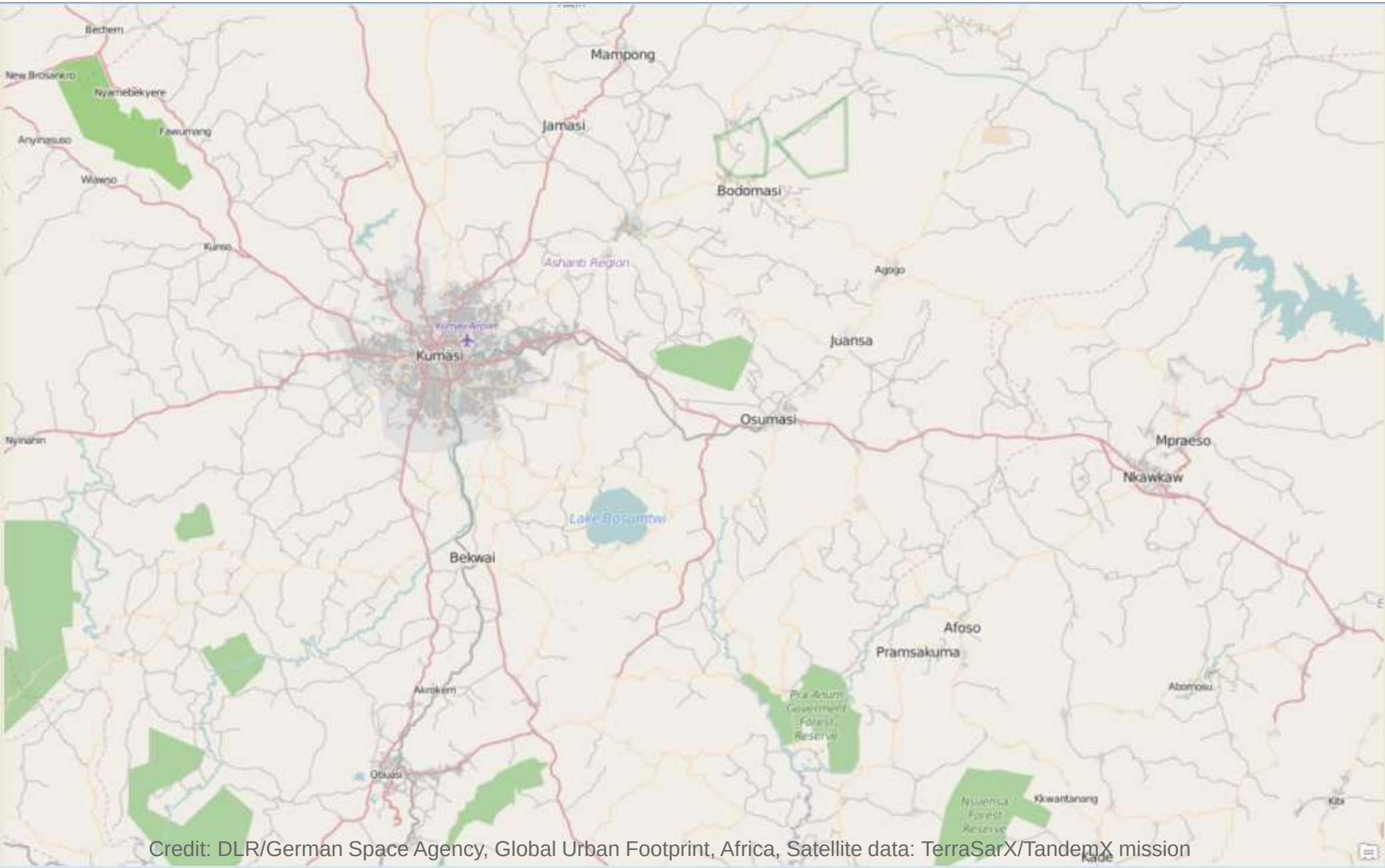
Non Urban
Urban 2003
Urban 2012

Credit: DLR/German Space Agency, Satellite data: TerraSarX/TandemX mission, Landsat, ERS, Envisat


Credit: DLR/German Space Agency, Area of Interest in East Africa

| World Bank | Data Type | Spatial Resolution | Data Temporal Range | Area of Interest |
|---|---|---|---|---|
| Phase 1 (01.04.2015 - 31.03.2016) | ASAR WSM | 75m | 2002-2003 | East Africa |
| | Sentinel-1 IW GRDH | 10m | 2014-2015 | Addis Ababa<br>Dar Es Salaam<br>Nairobi |
| Phase 2 (01.04.2016 – 31.03.2017) | ASAR WSM | 75m | 2002-2003 | remaining part of the African continent |
| | Sentinel-1 IW GRDH | 10m | 2014-2016 | Kigali<br>Uganda<br>(Addis Ababa)<br>(Dar Es Salaam)<br>(Nairobi) |

Credit: DLR/German Space Agency



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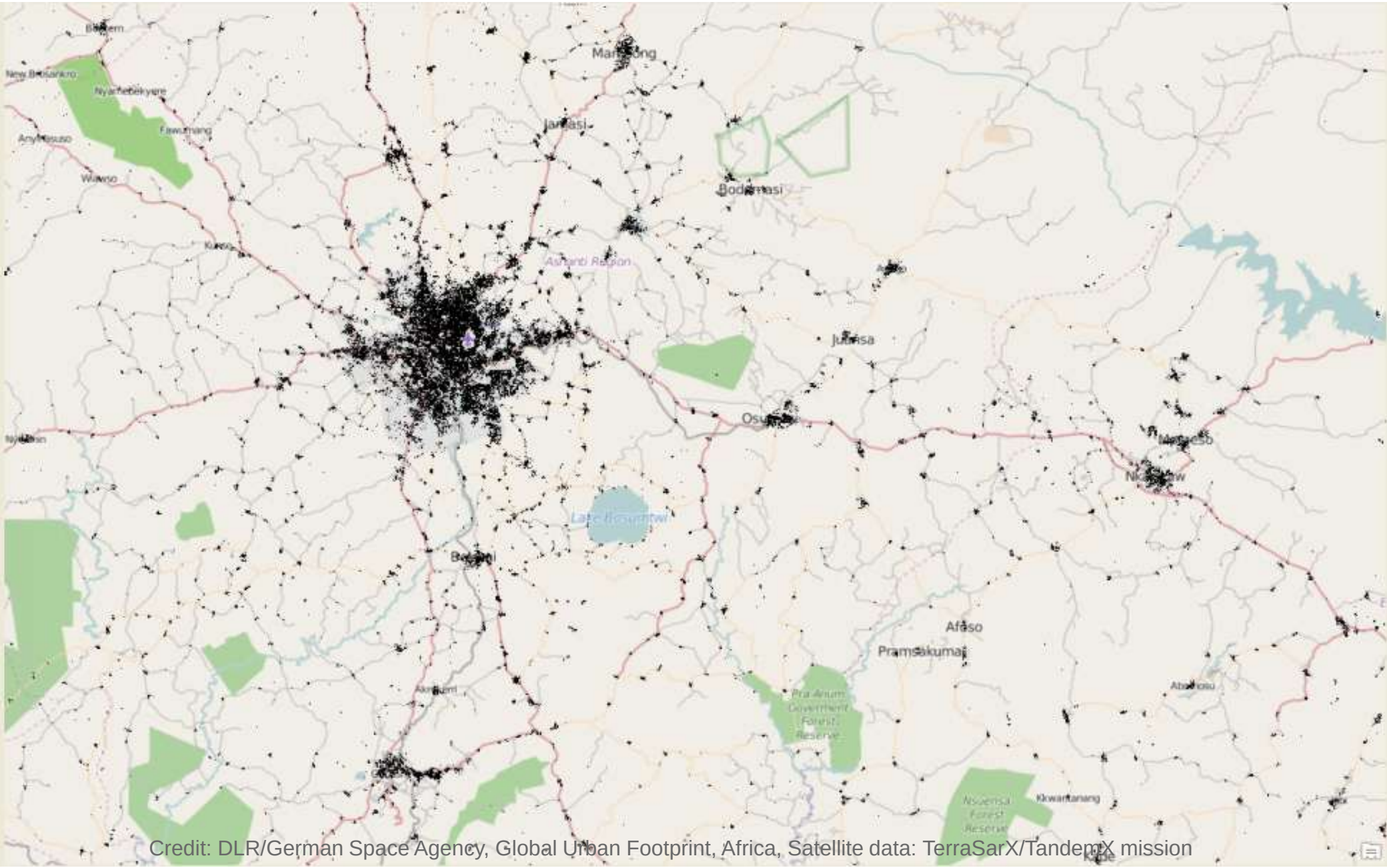


Credit: DLR/German Space Agency, Global Urban Footprint, Africa, Satellite data: TerraSarX/TandemX mission

# ESA Urban Thematic Exploitation Platform (Urban TEP)

- Primary thematic fields of application for urban TEP
  - Global monitoring, analyses and products.
  - On-demand hot spot observations.
  - Comparative and historical studies.
  - Establishment of long-term urban observations.
- Key characteristics of urban TEP
  - Free and open use of state-of-the art infrastructure, algorithms and products.
  - Efficient exploitation of available data streams and archives (i.a., EO-based).
  - Use of high-performance computing and data management infrastructure.
  - Advanced analysis , data fusion and visualisation capabilities.
  - Validated and benchmarked techniques and products.
  - Profit from network of experts and best practice applications.
  - Functionalities for quick implementation and conversion of innovations and customized adaptations into services.

Credit: DLR/German Space Agency, GISAT, Brockmann Consult, Terradue, ITI, Urban TEP Kick Off Meeting, Frascati March 2015

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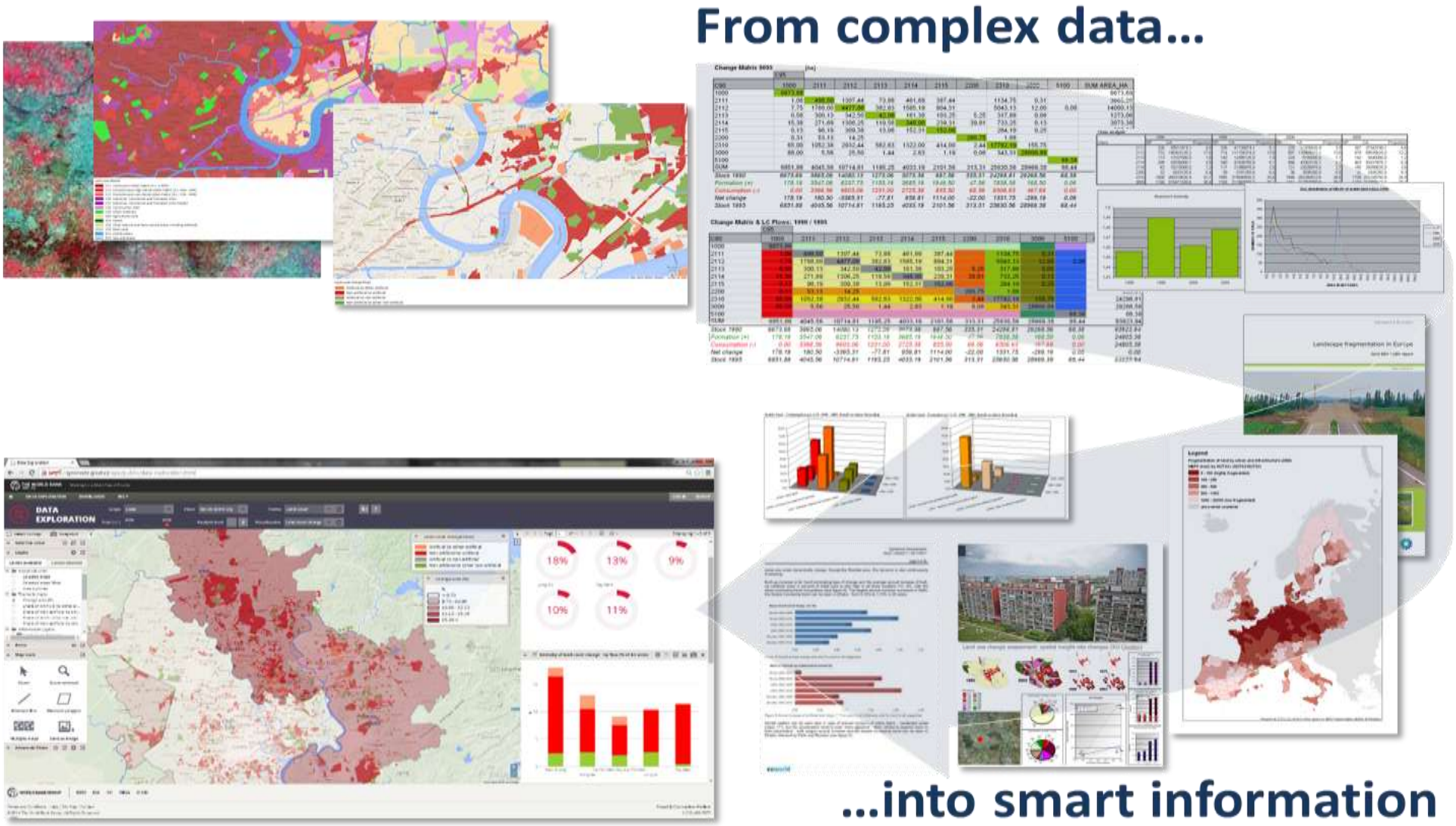


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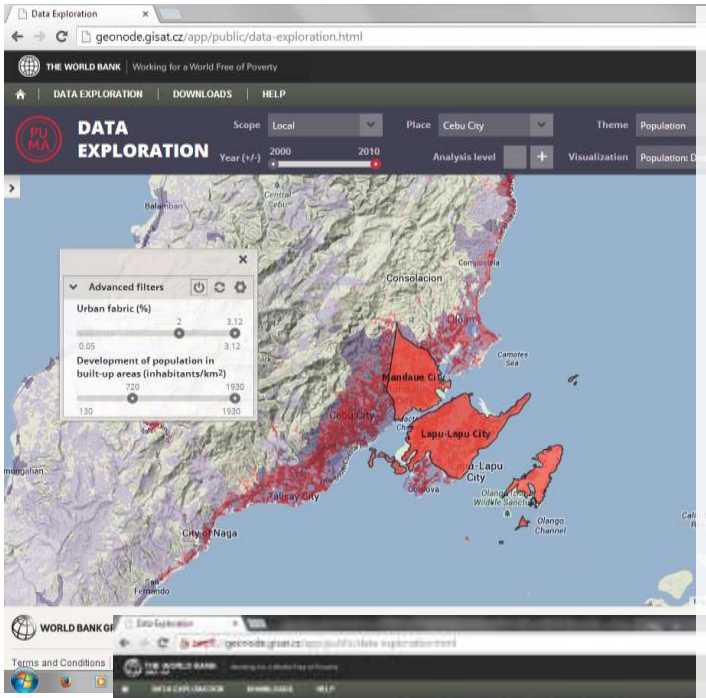
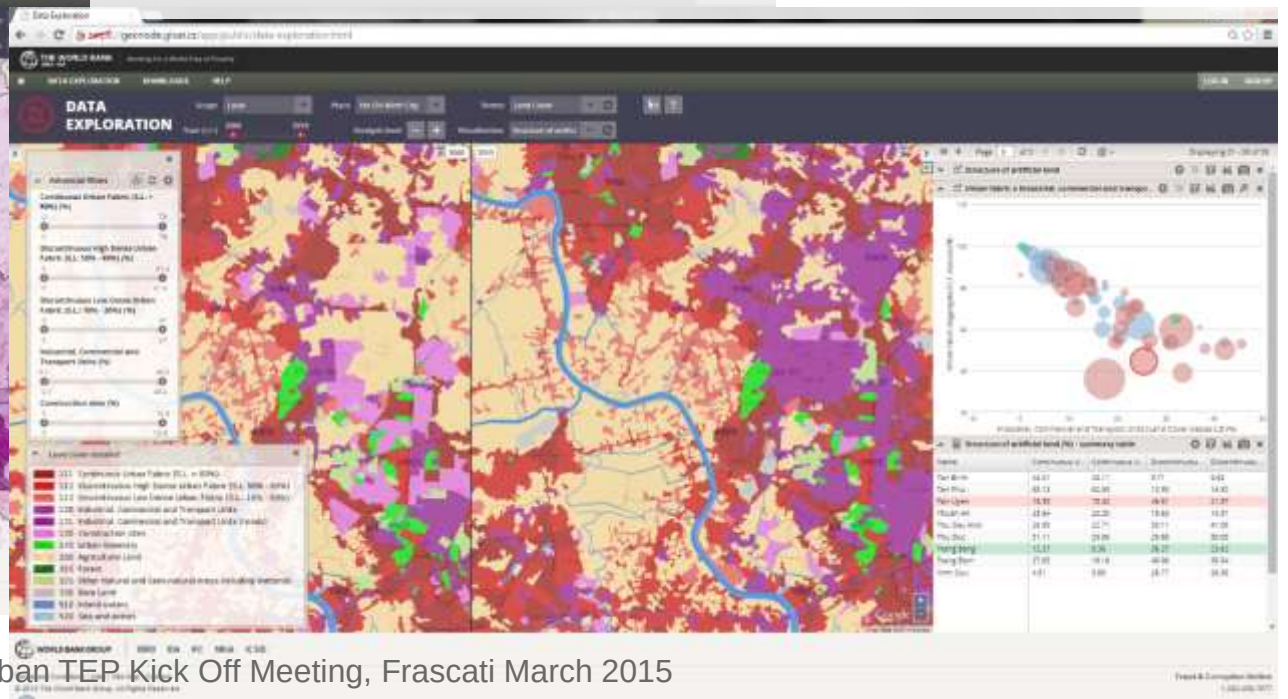







## Back-end

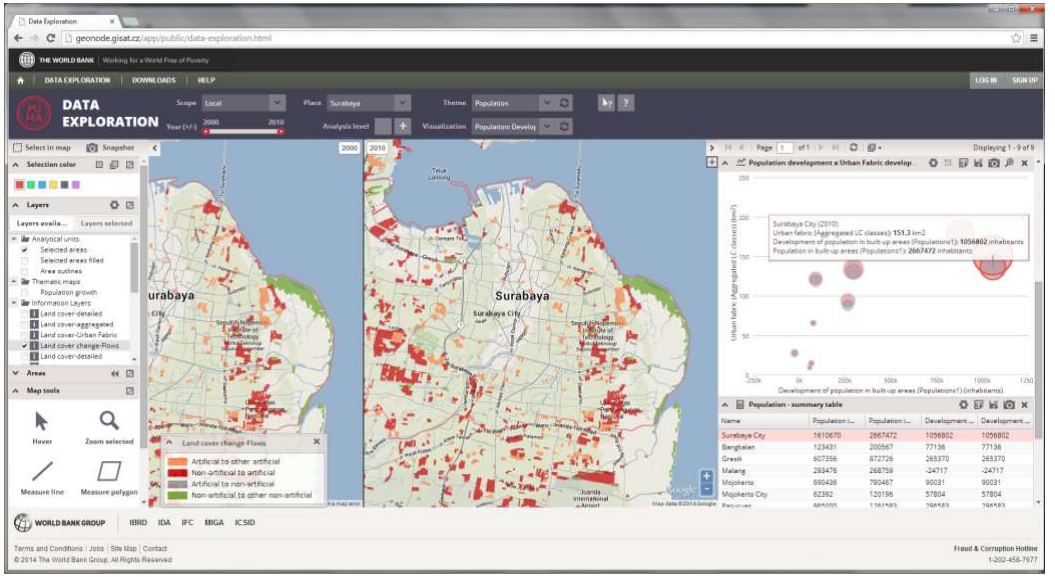
- On-demand computation capabilities - modeling, what if support
- More power, more scalability – both for computation, and access demand
- Through sandboxes/parallel (cloud) computing
- More data - open data access
  - EO data and services (Copernicus, Landsat8) catalogues
  - open data using OpenLinkedData approaches (RDF, SPARC/STRABON) MELODIES

Credit: GISAT, Urban TEP Kick Off Meeting, Frascati March 2015

# ESA Urban Thematic Exploitation Platform (Urban TEP)

- Multi-scale approach needed reflecting various scales of urban structures for information support.

- User communities on all levels:
  - Global
  - Regional
  - National
  - Local

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# Example of regional / local dataset

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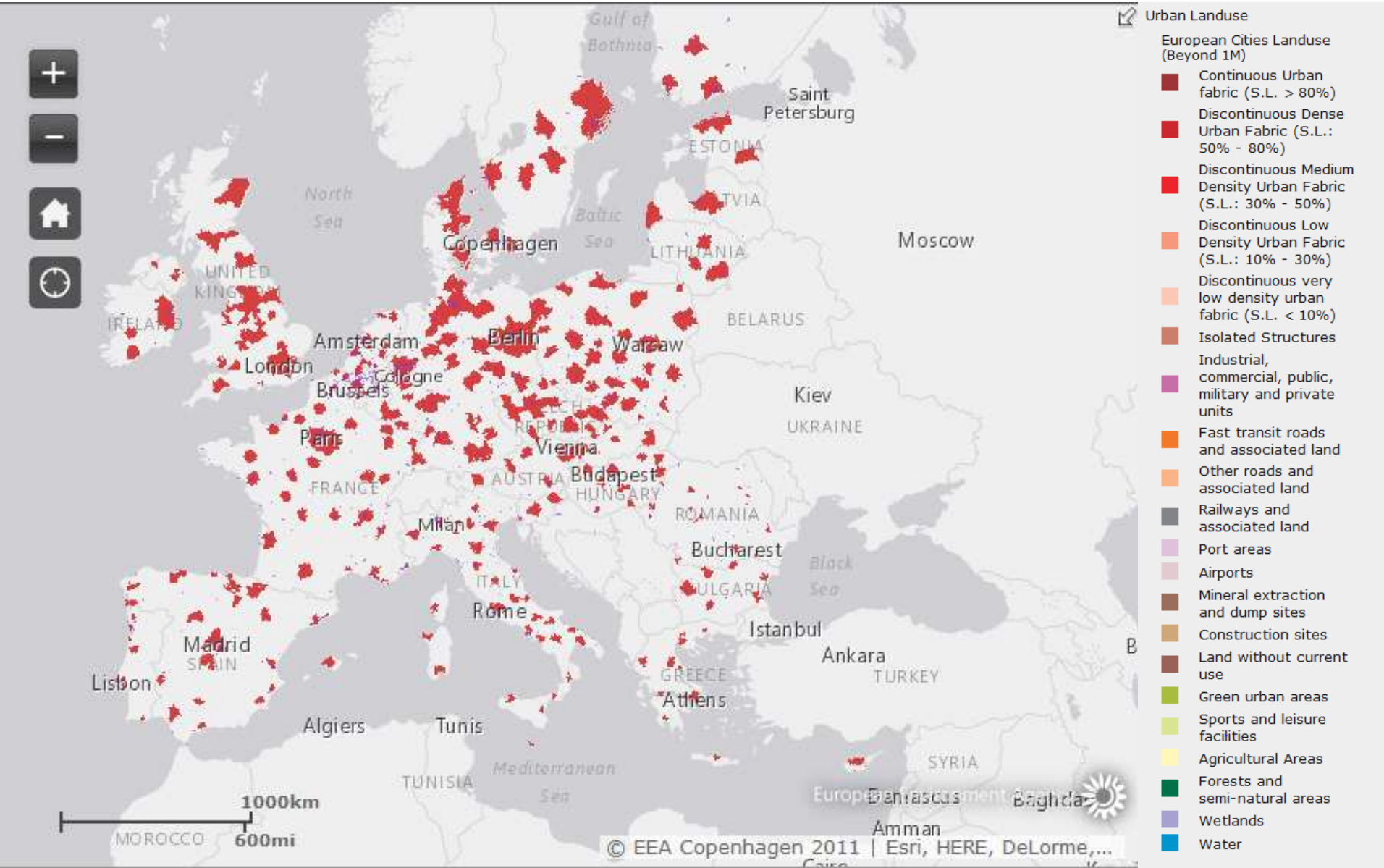

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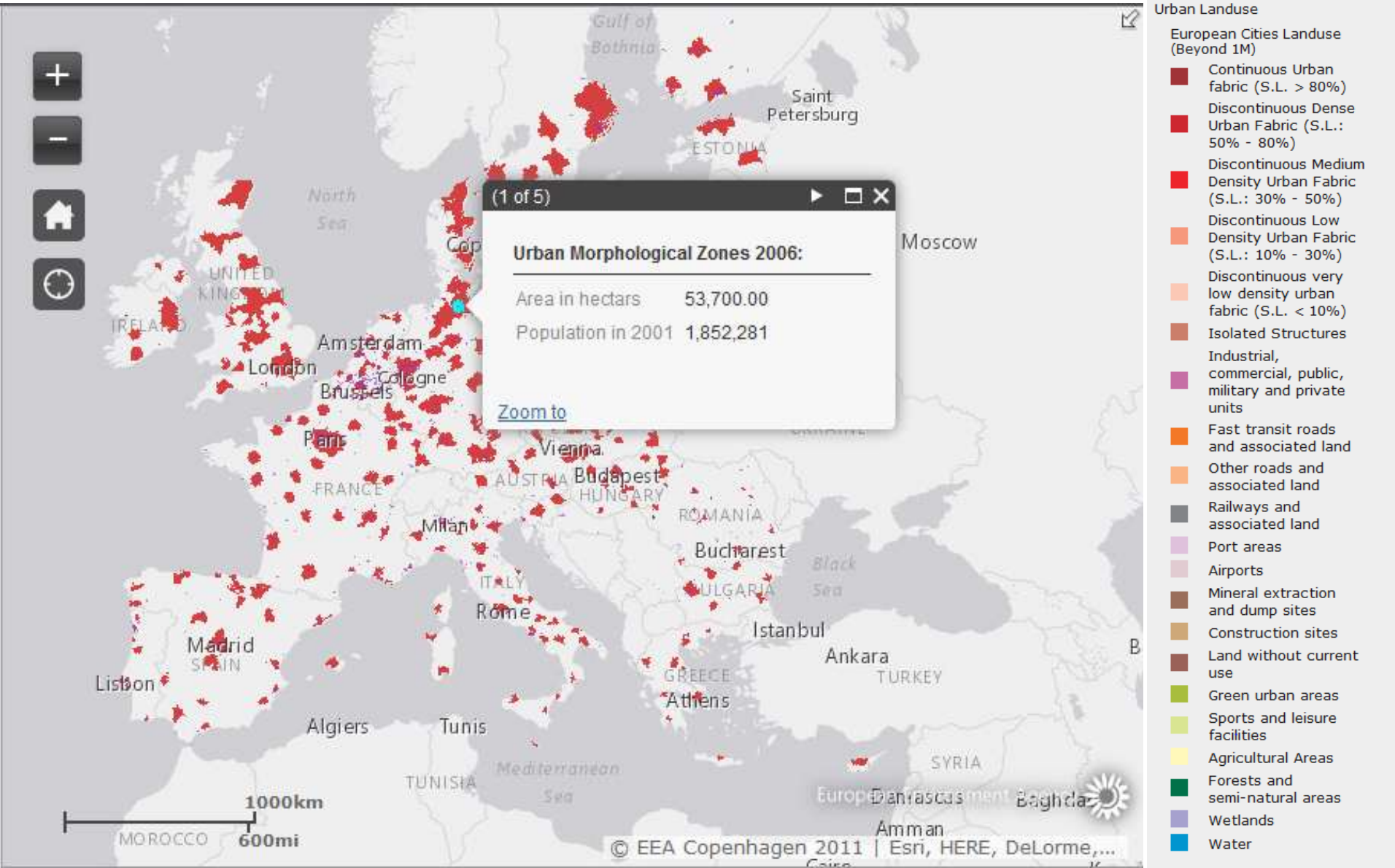

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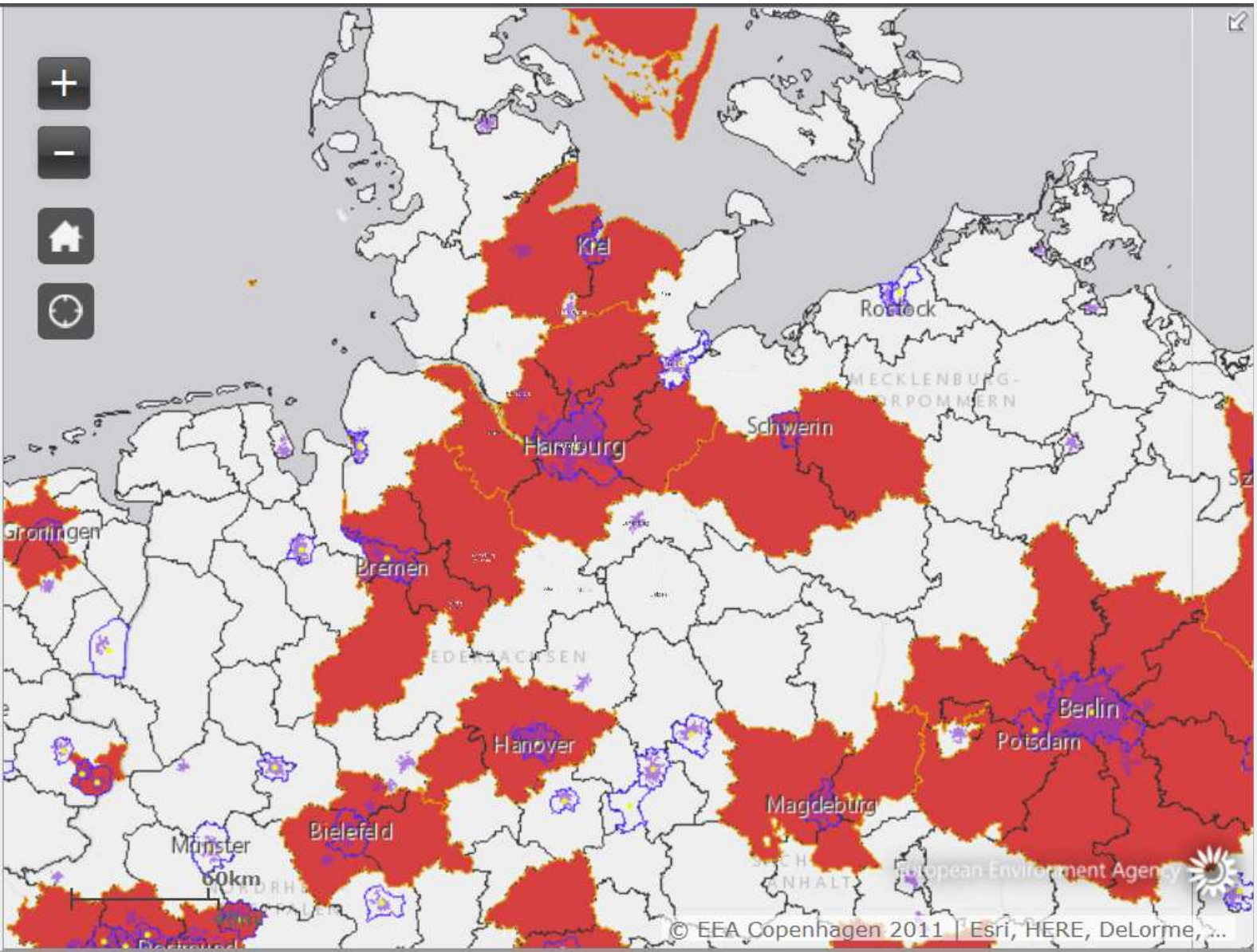


Urban Landuse

European Cities Landuse (Beyond 1M)

- Continuous Urban fabric (S.L. > 80%)
- Discontinuous Dense Urban Fabric (S.L.: 50% - 80%)
- Discontinuous Medium Density Urban Fabric (S.L.: 30% - 50%)
- Discontinuous Low Density Urban Fabric (S.L.: 10% - 30%)
- Discontinuous very low density urban fabric (S.L. < 10%)
- Isolated Structures
- Industrial, commercial, public, military and private units
- Fast transit roads and associated land
- Other roads and associated land
- Railways and associated land
- Port areas
- Airports
- Mineral extraction and dump sites
- Construction sites
- Land without current use
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- Agricultural Areas
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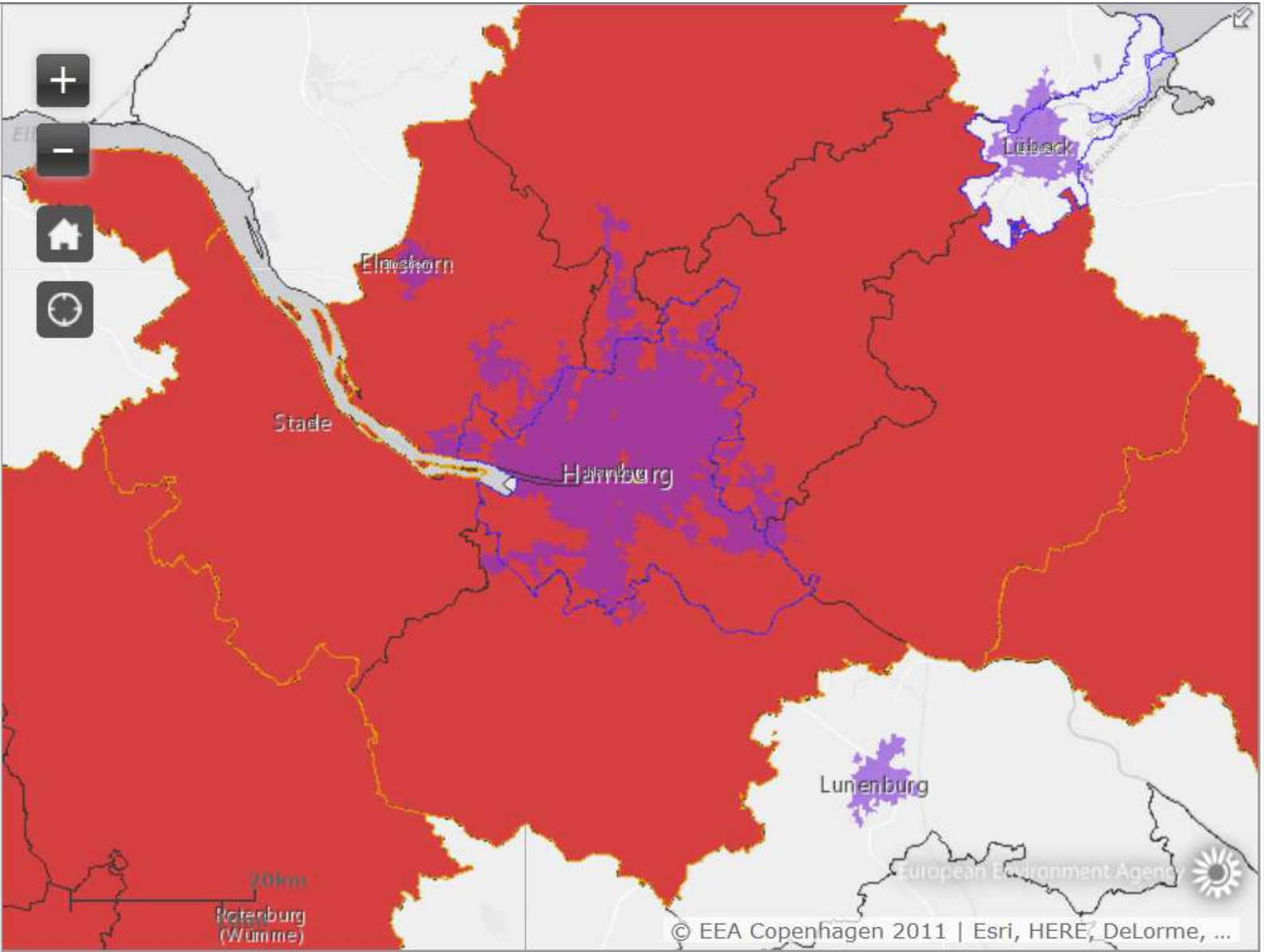


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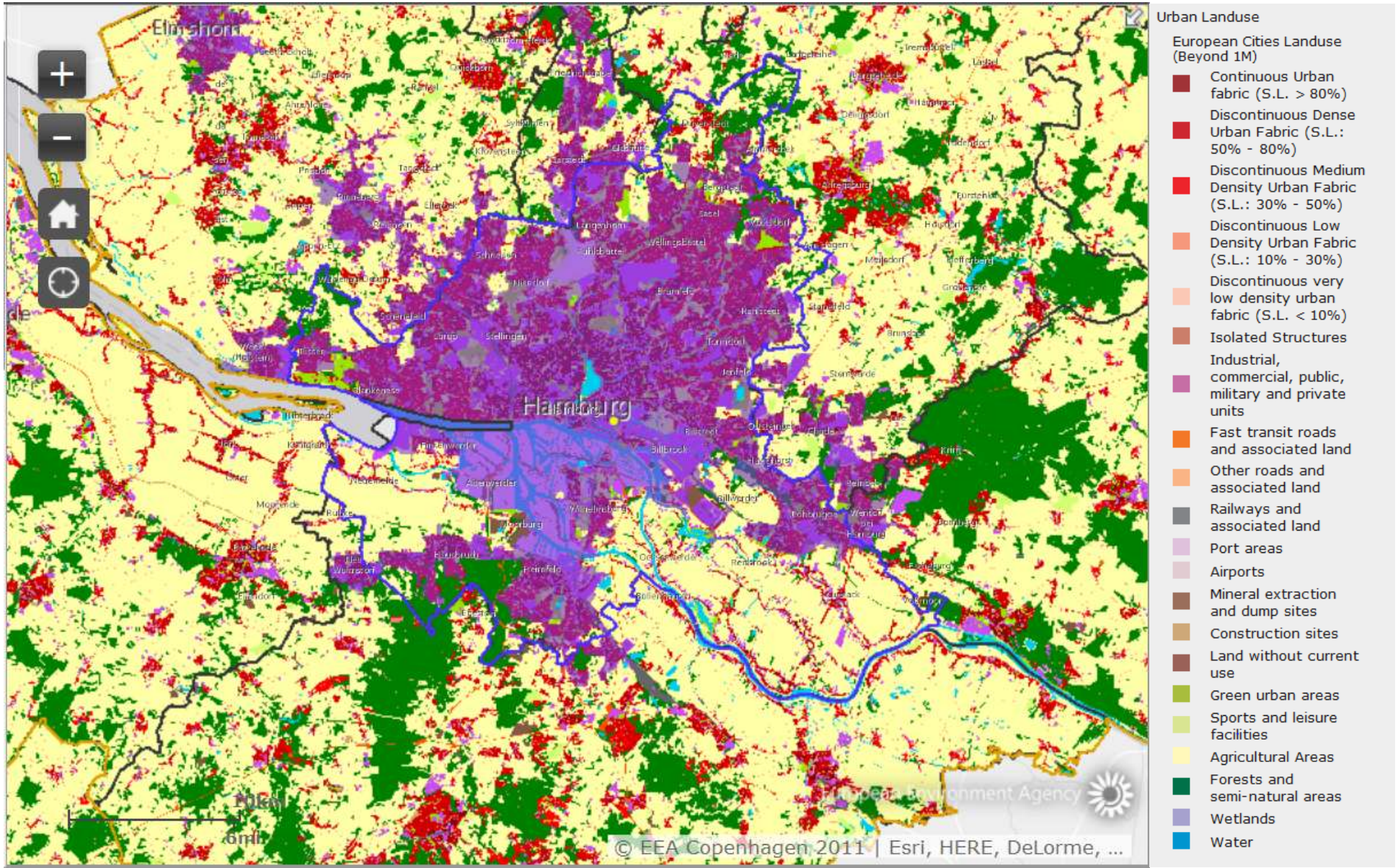

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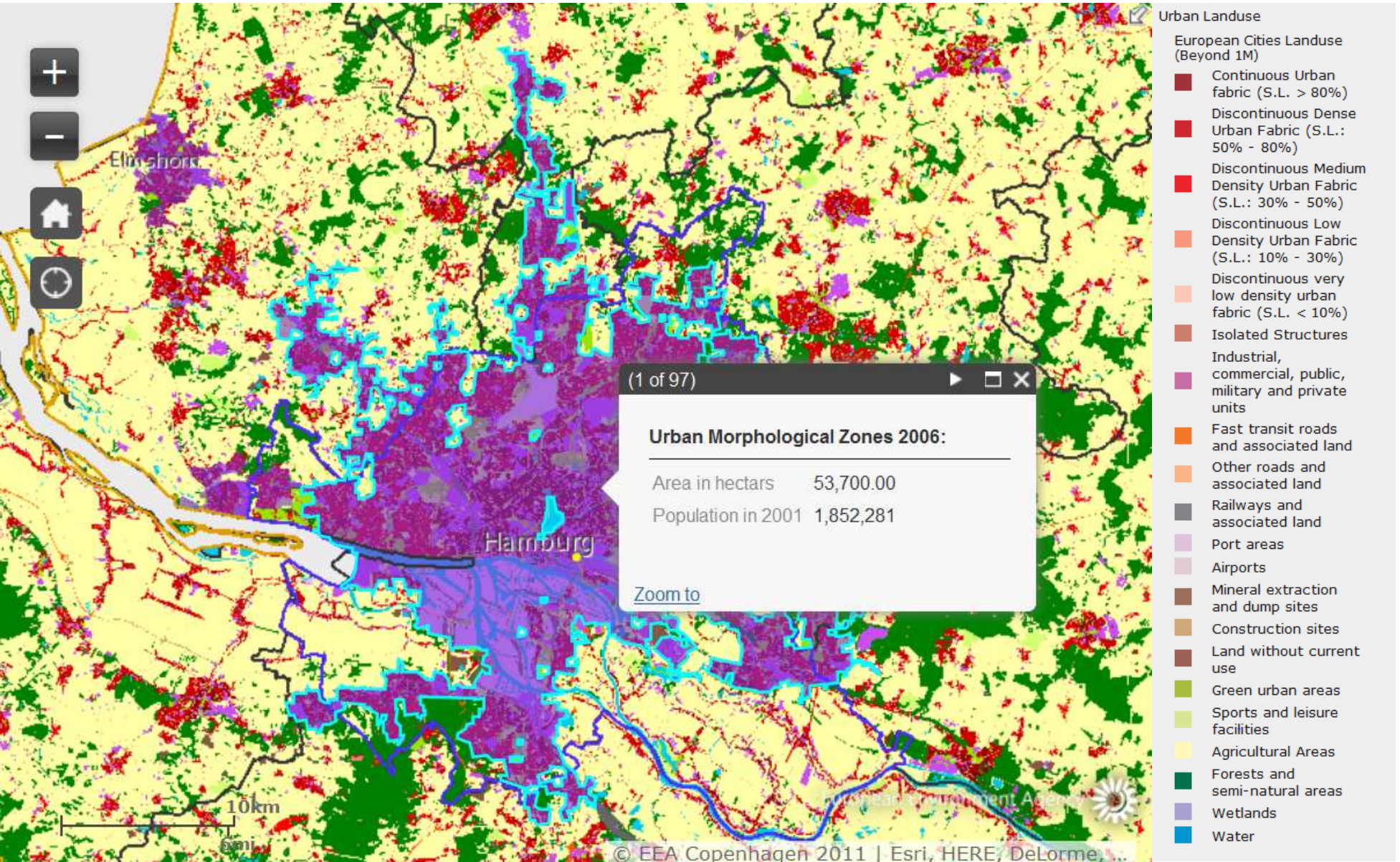

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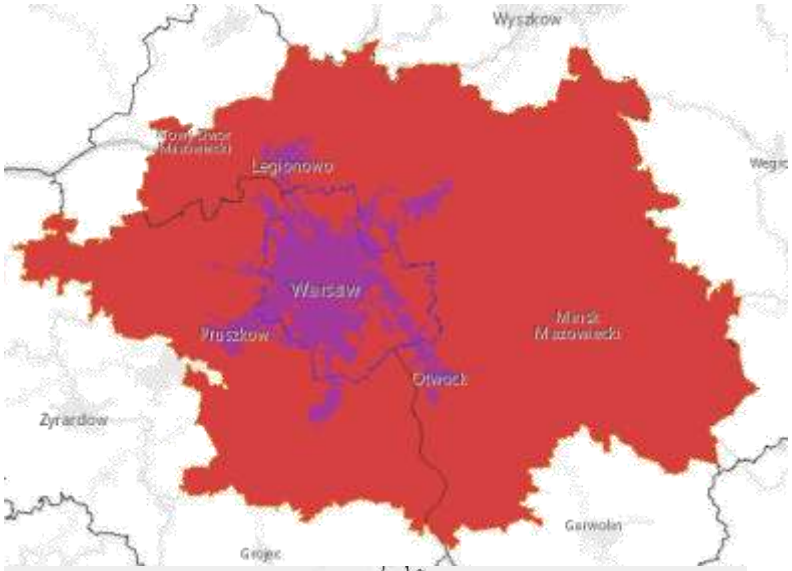


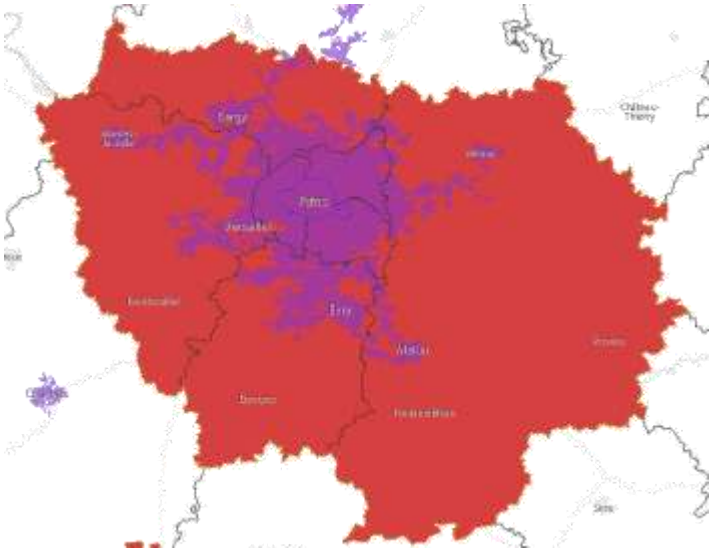

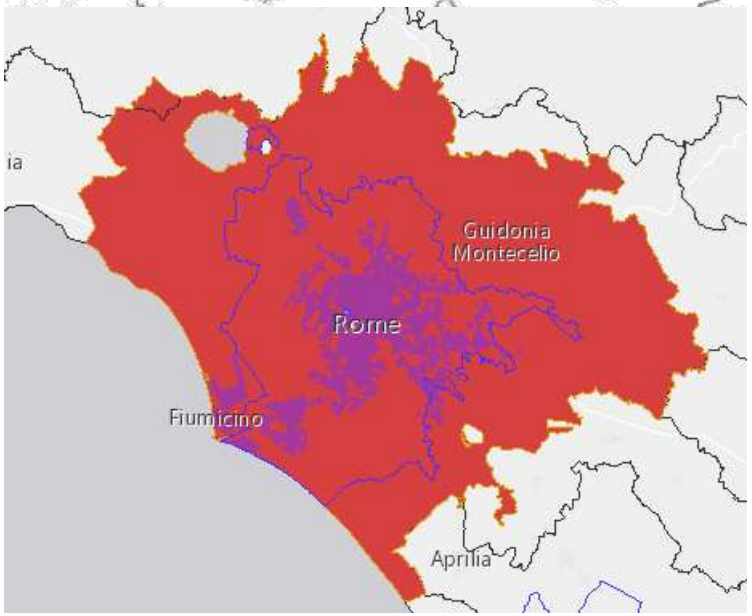


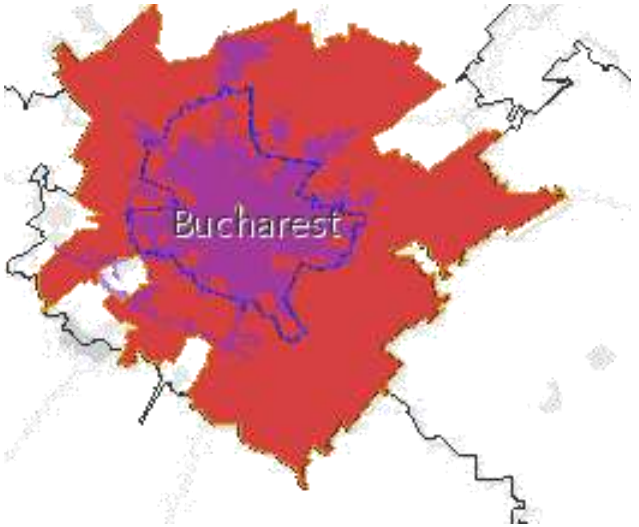


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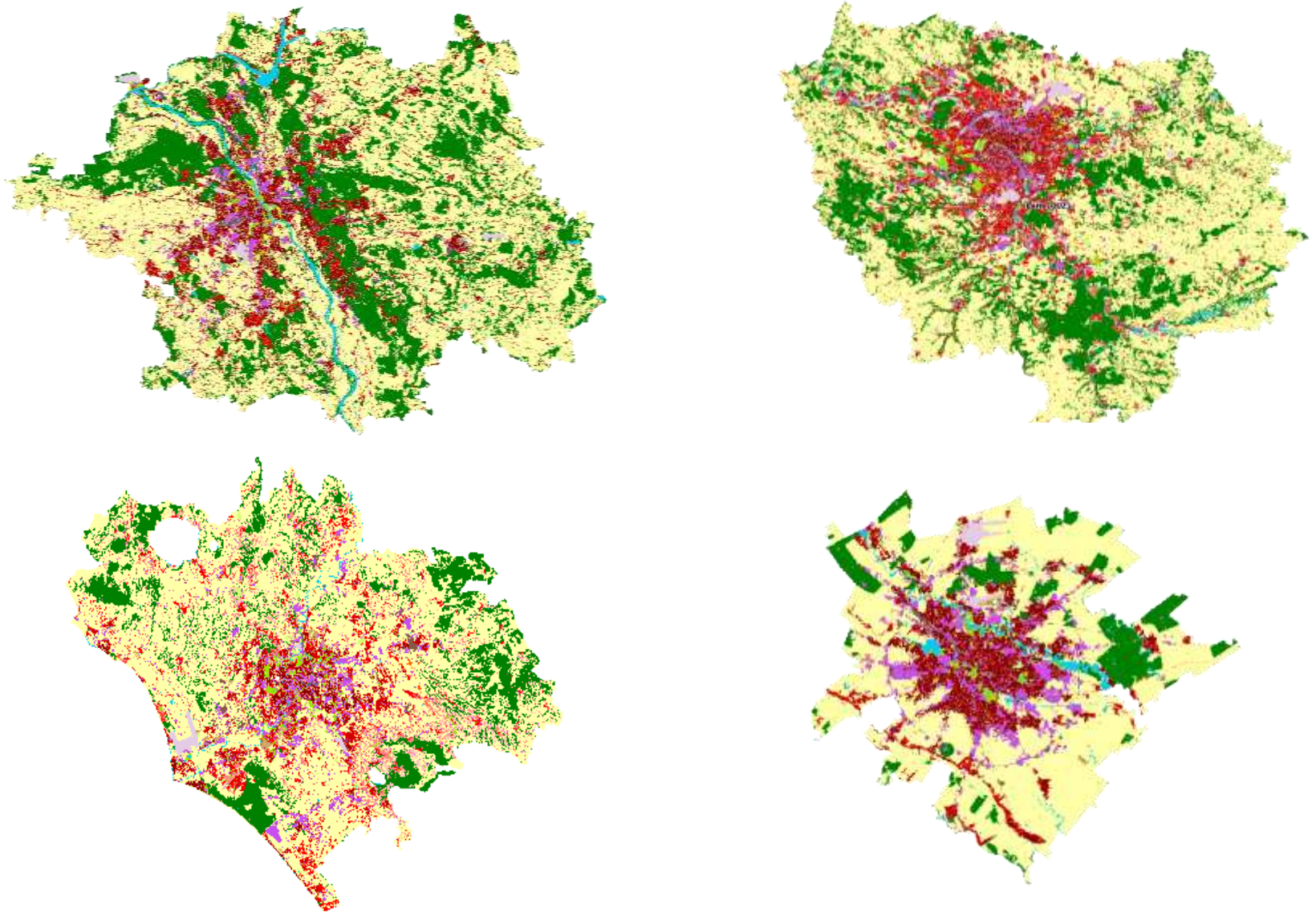
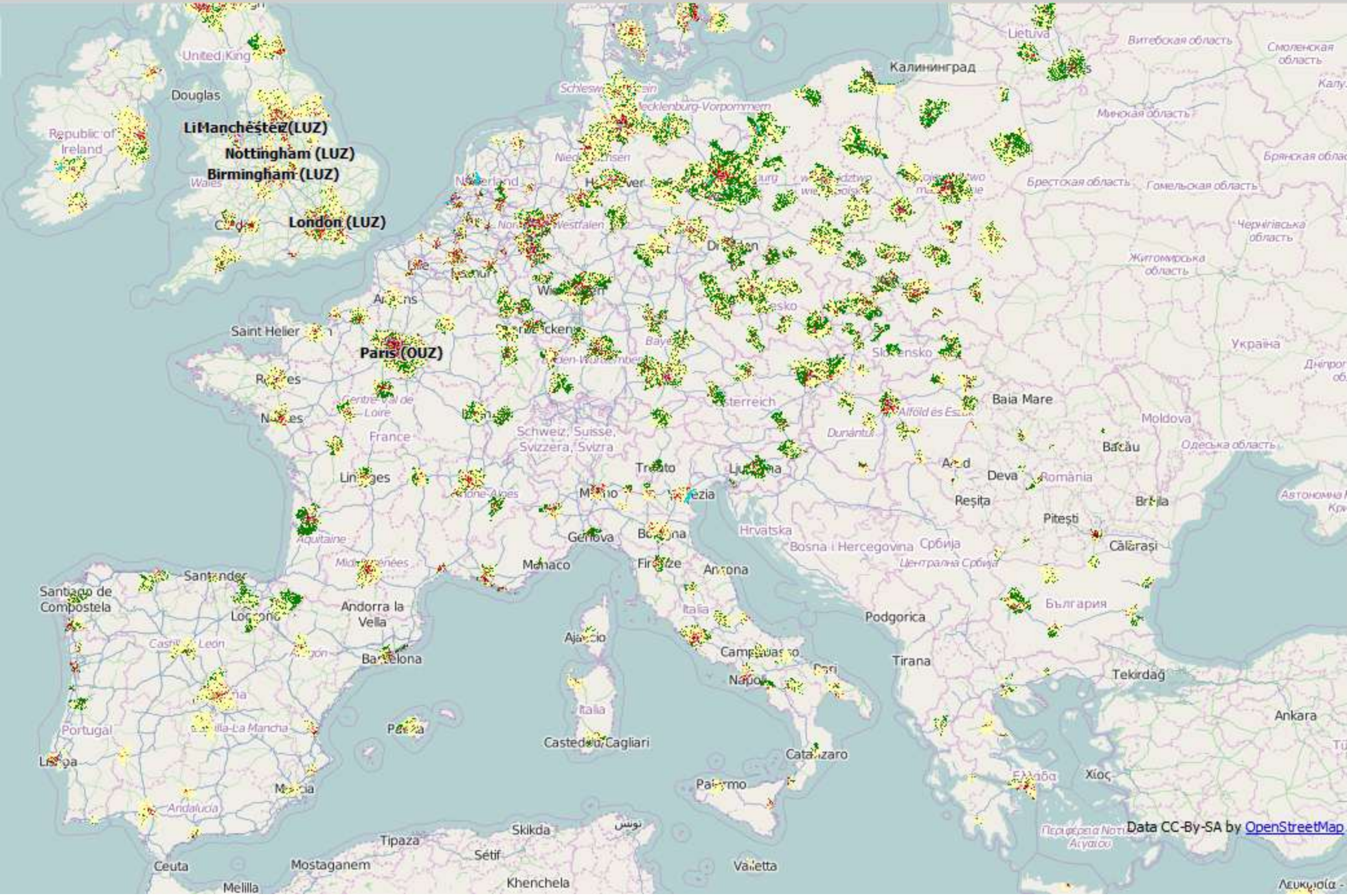
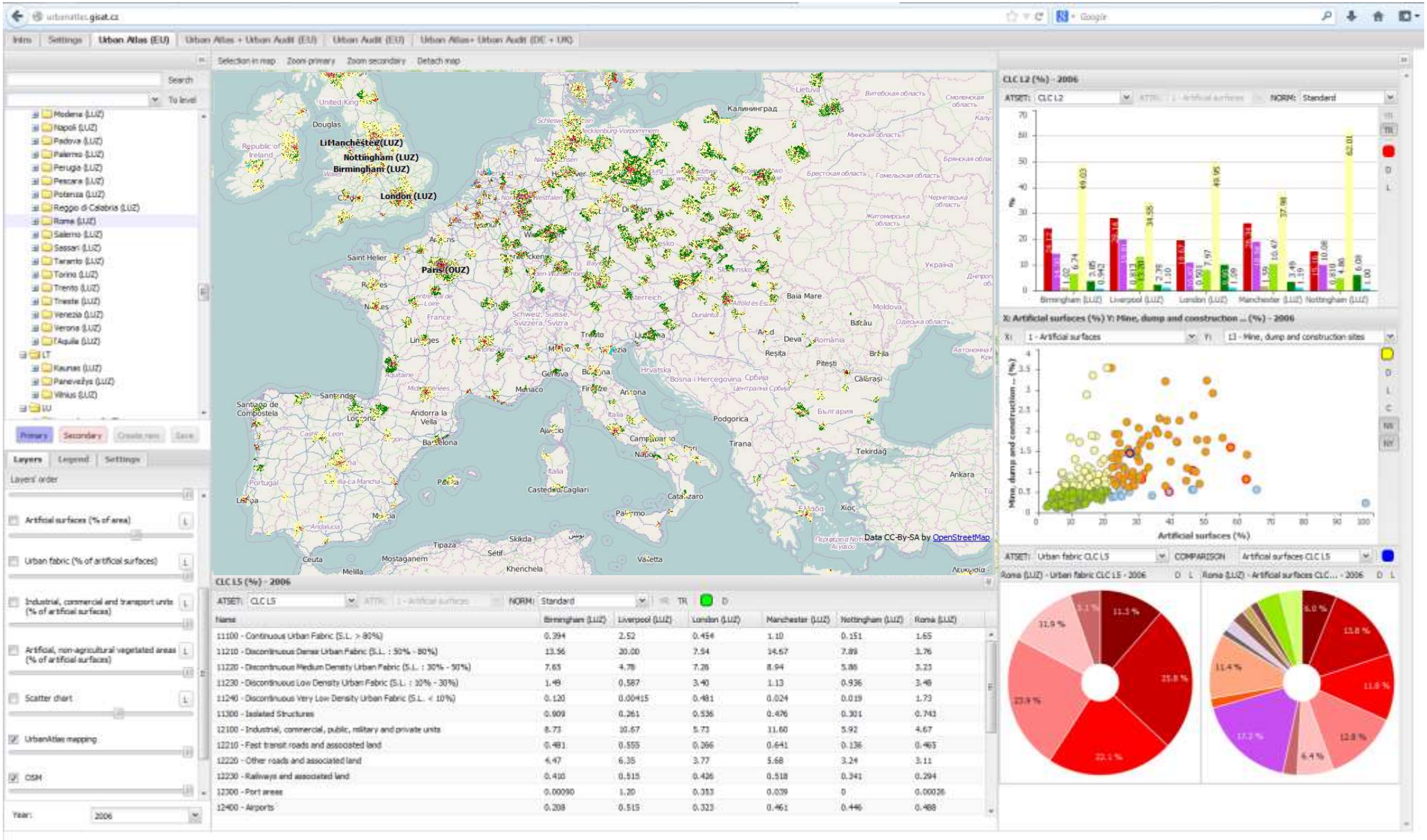
# Example of regional / local dataset

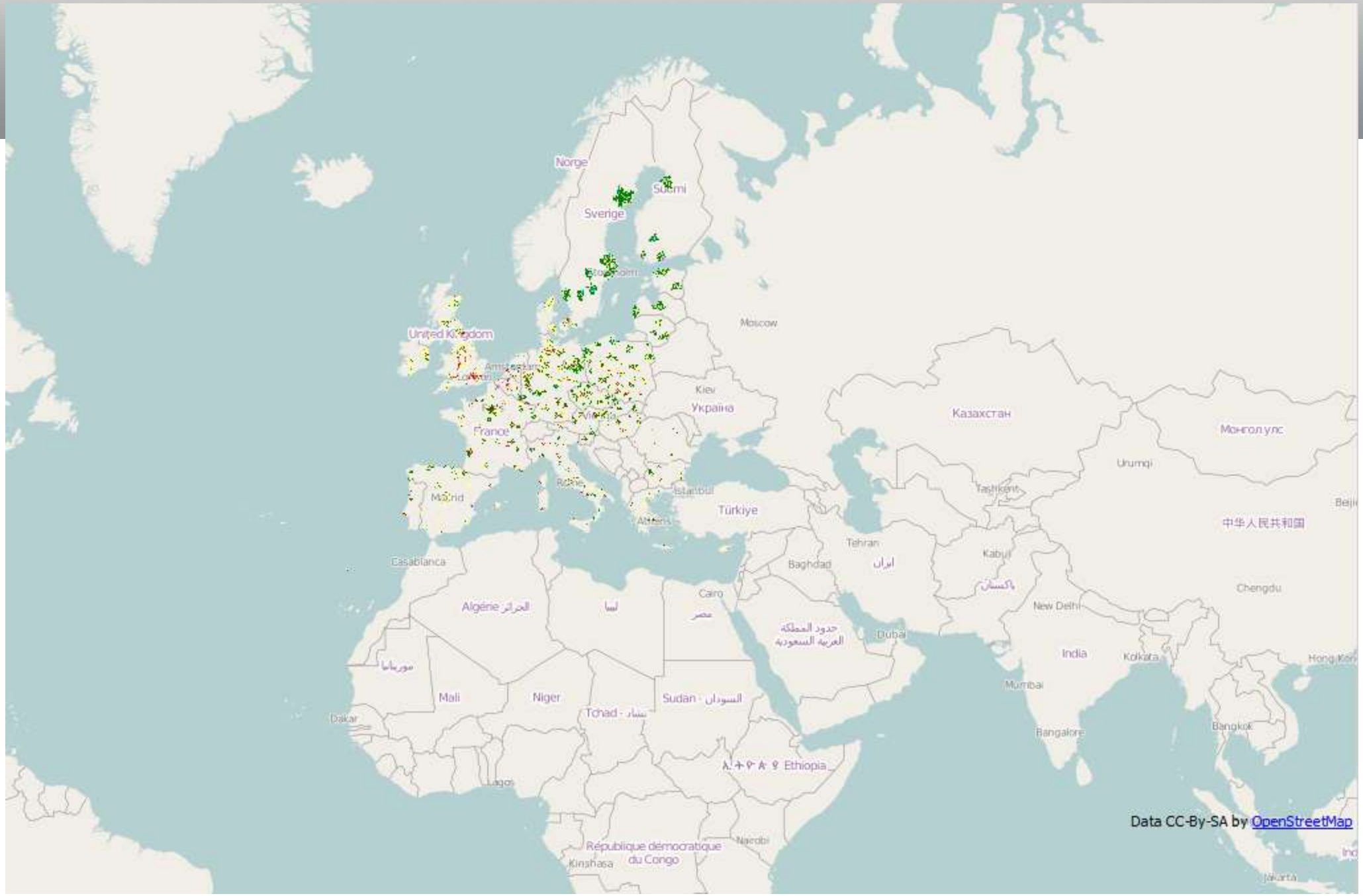
## European Urban Atlas




Douglas
Manchester (LUZ)
Nottingham (LUZ)
Birmingham (LUZ)
London (LUZ)
Paris (OUZ)
Калининград
Data CC-By-SA by OpenStreetMap




Credit: GISAT, Urban Atlas Plus project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Sverige
Suomi
Moscow
United Kingdom
France
Kiev
Україна
Казахстан
Монгол улс
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Türkiye
Madrid
Casablanca
Algérie
Cairo
Tehran
Baghdad
Kabul
Chengdu
New Delhi
India
Kolkata
Dubai
Mumbai
Bangkok
Rangalore
Mali
Niger
Sudan
Tchad
Ethiopia
Dakar
Lagos
Nairobi
Kinshasa
République démocratique du Congo
Data CC-By-SA by OpenStreetMap


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République démocratique du Congo
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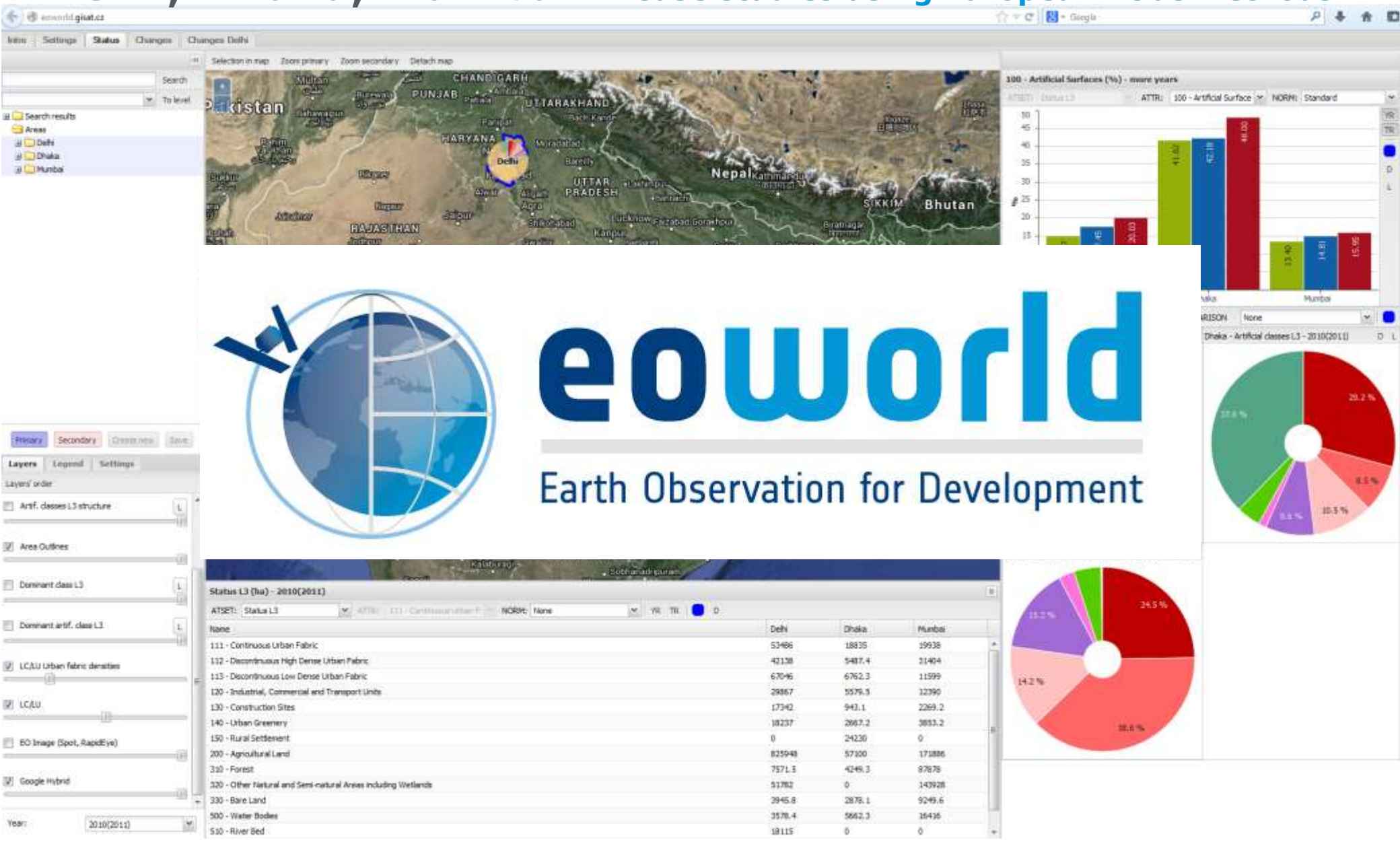
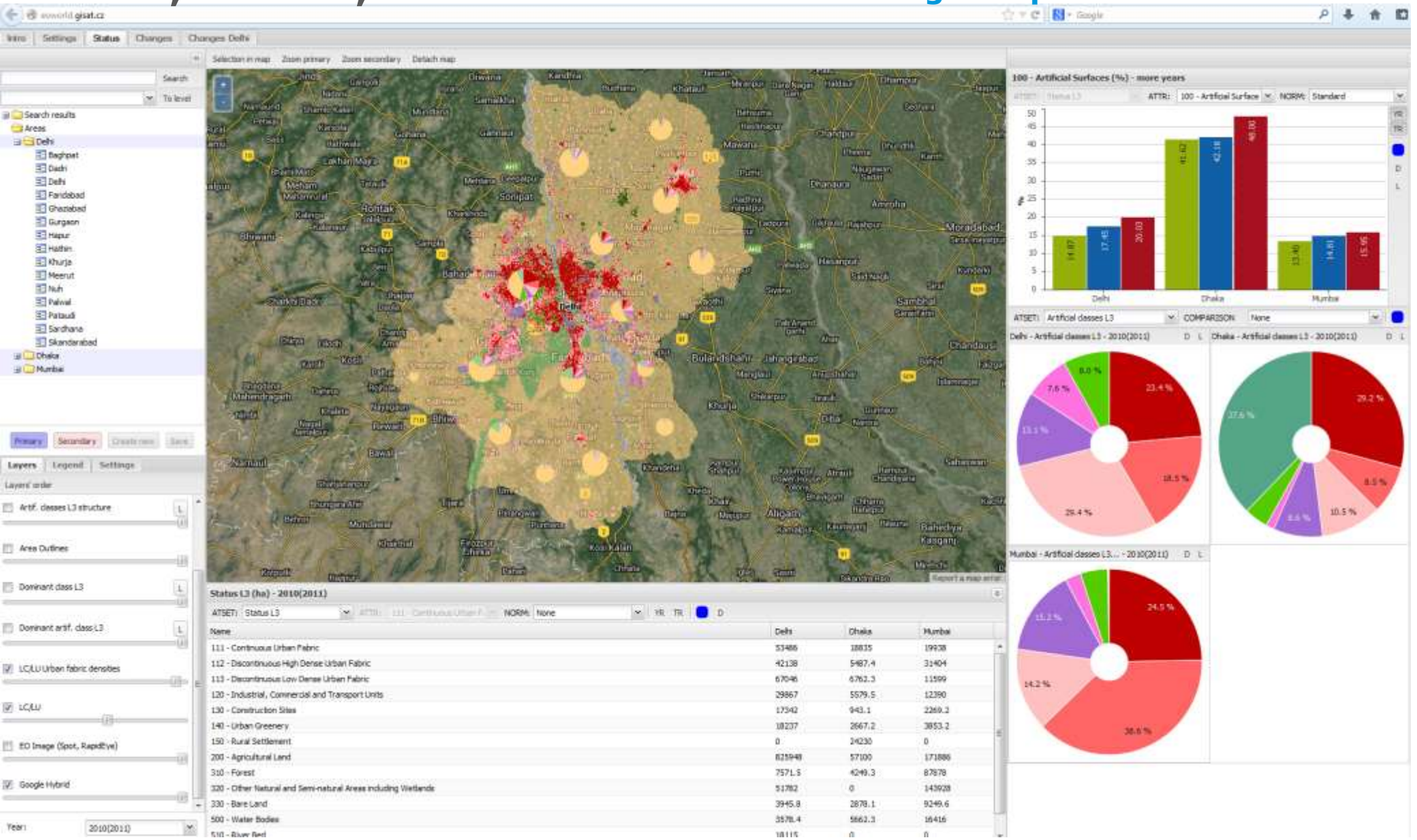
Data CC-By-SA by OpenStreetMap

# Delhi, Dhaka, Mumbai - Case studies using European Atlas Methods




Credit: GISAT, eoworld project

# Delhi, Dhaka, Mumbai - Case studies using European Atlas Methods

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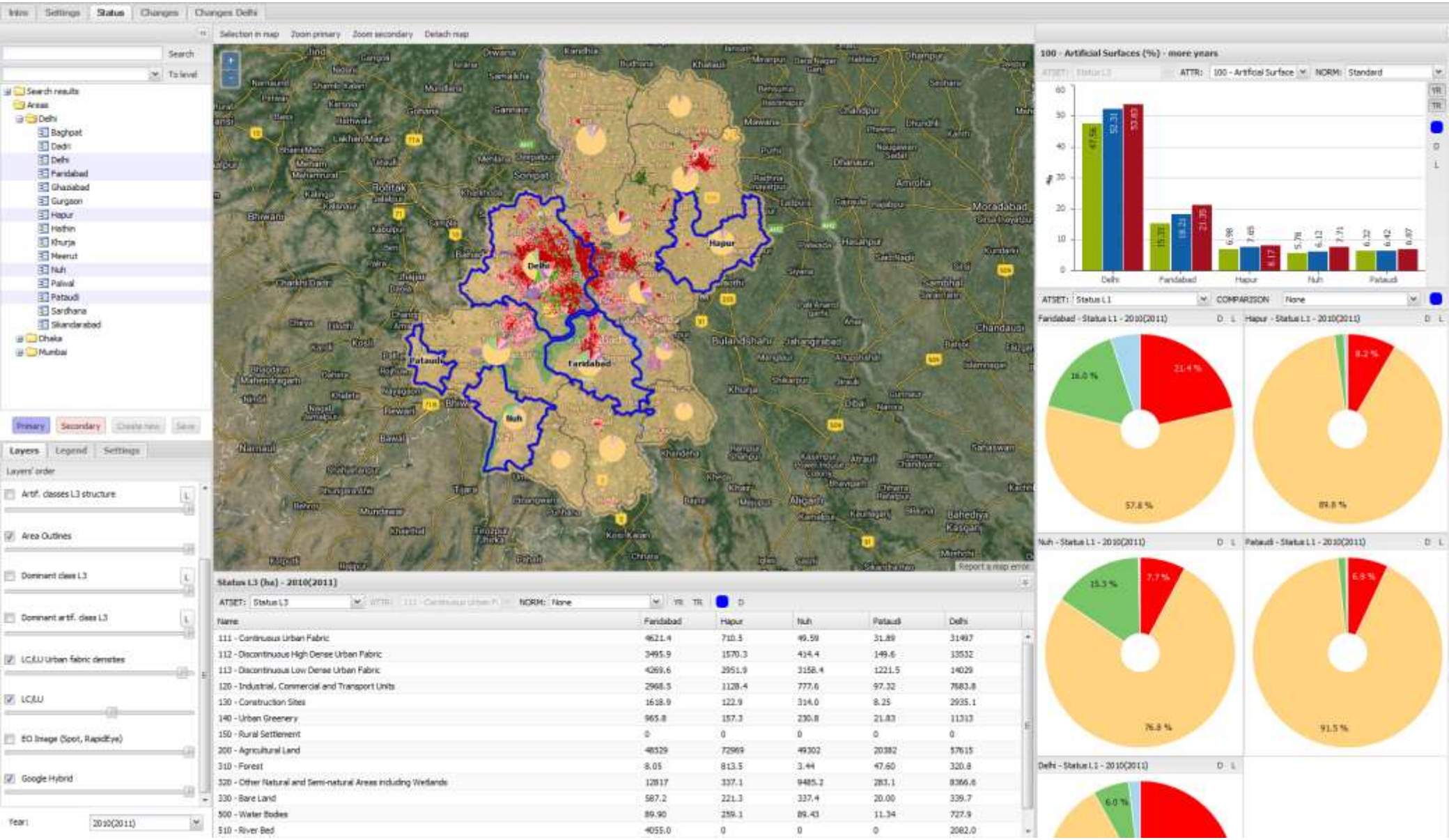
# Delhi, Dhaka, Mumbai - Case studies using European Atlas Methods

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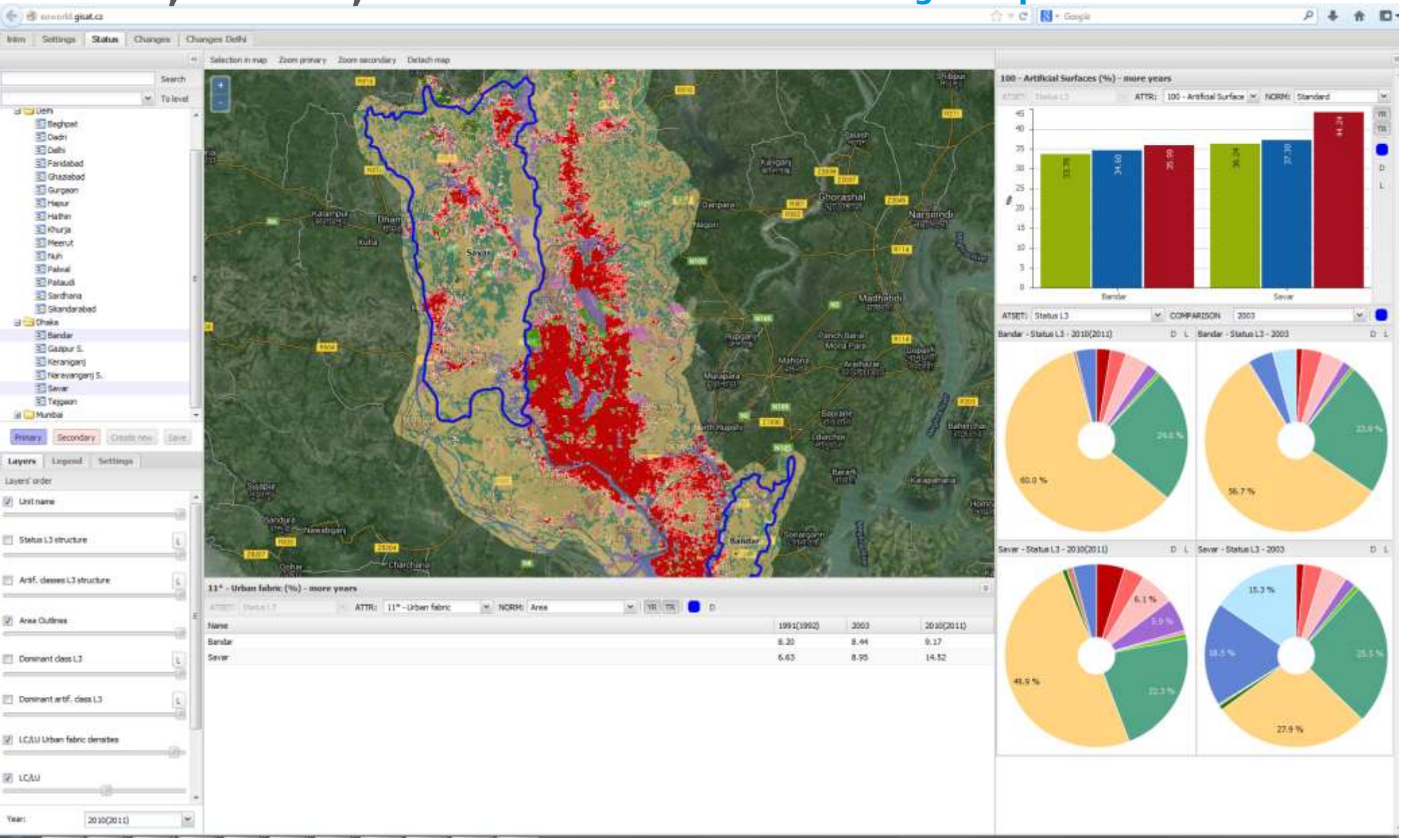
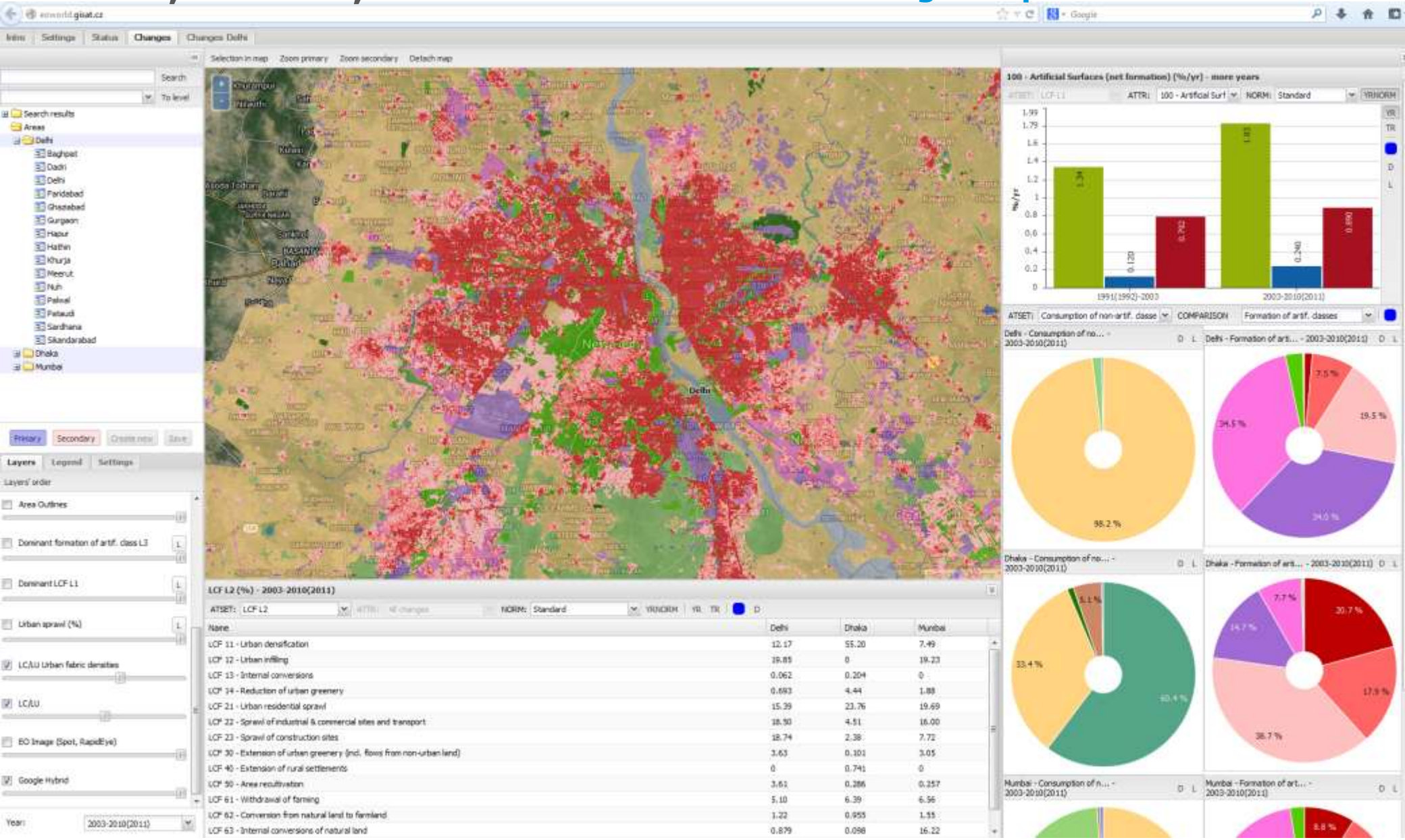



Credit: GISAT, eoworld project

# Delhi, Dhaka, Mumbai - Case studies using European Atlas Methods



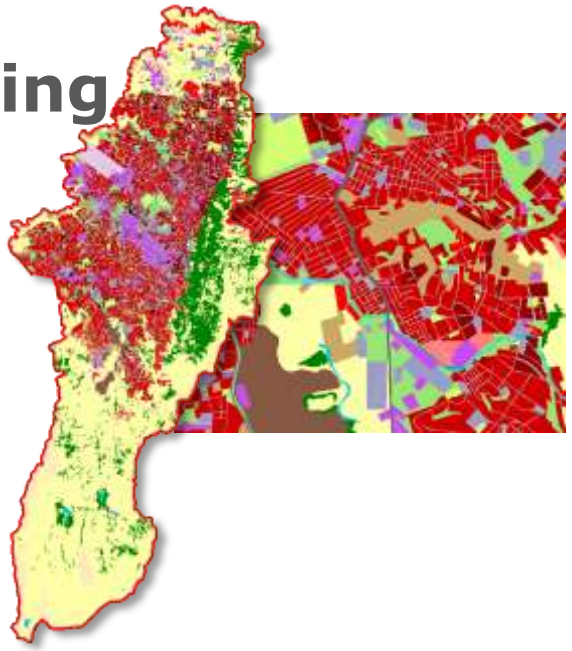

Credit: GISAT, eoworld project

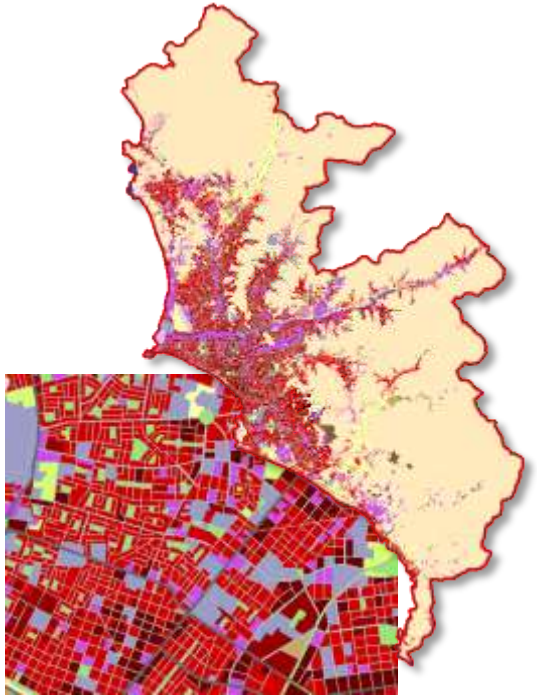
# List of cities outside Europe mapped using Urban Atlas methodology

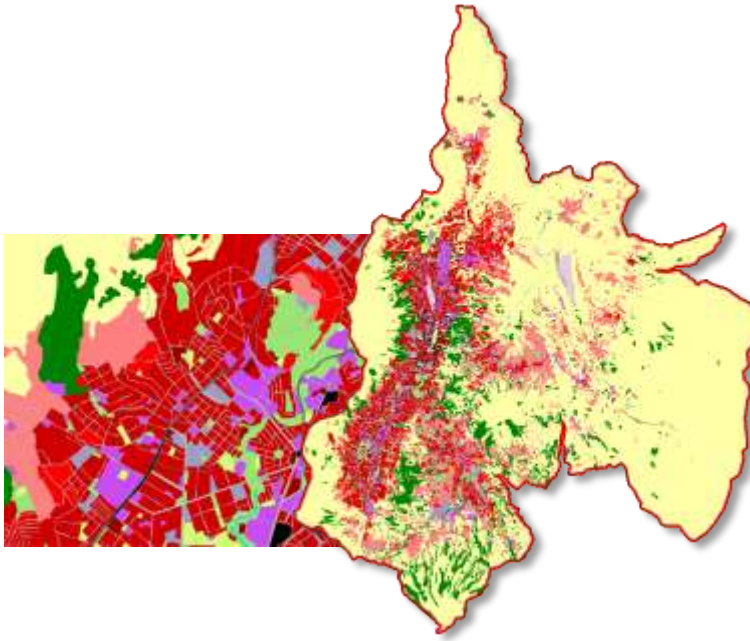
- **Dheli**
- **Dhaka**
- **Mumbai**
- **Lima**
- **Bogota**
- **Quito**
- **Jalalbad**
- **Karach**
- **Chittagong**
- **Colombo**
- **Ho Chi Min City**
- **Yogyakarta**
- **Georgetown (Guyana)**
- **Rio de Janeiro**
- **Manila**
- **Cebu City**
- **Hai Phong**
- **Surabaya**
- **Ulanbaatar**

Mapping/monitoring principles:

- Two to three decades of urban growth 1990, 2000, 2010
- At least 13 urban classes
- Showing land conversions across classes
- Using the same definitions for comparable results







# From maps to indicators

**Indicator 1:** Urban growth

**Indicator 2:** Growth of residential areas

**Indicator 3:** Growth of industrial areas

**Indicator 4:** Urban growth and population development

**Indicator 5:** Productivity of land consumption

**Indicator 6:** Urban sprawl intensity

**Indicator 7:** Land cover replaced by built-up area

**Indicator 8:** Land use

**Indicator 9:** Loss of natural areas

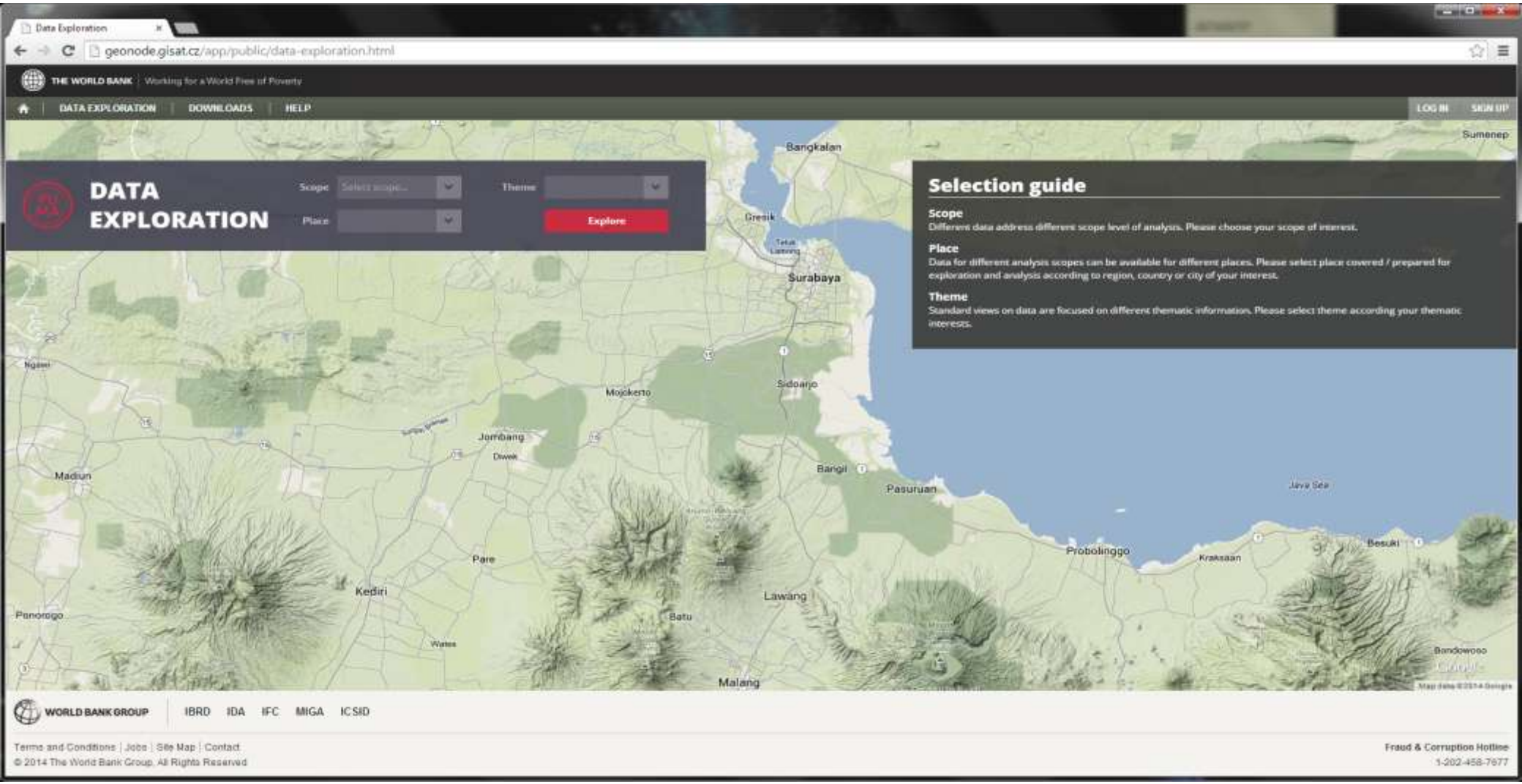
**Indicator 10:** Structural indicators

**Indicator 11:** Informal Settlements

# Platform for Urban Management and Analysis

## World Bank EAP Regional Urbanization Flagship // support tool

## http://puma.worldbank.org




Credit: GISAT for World Bank

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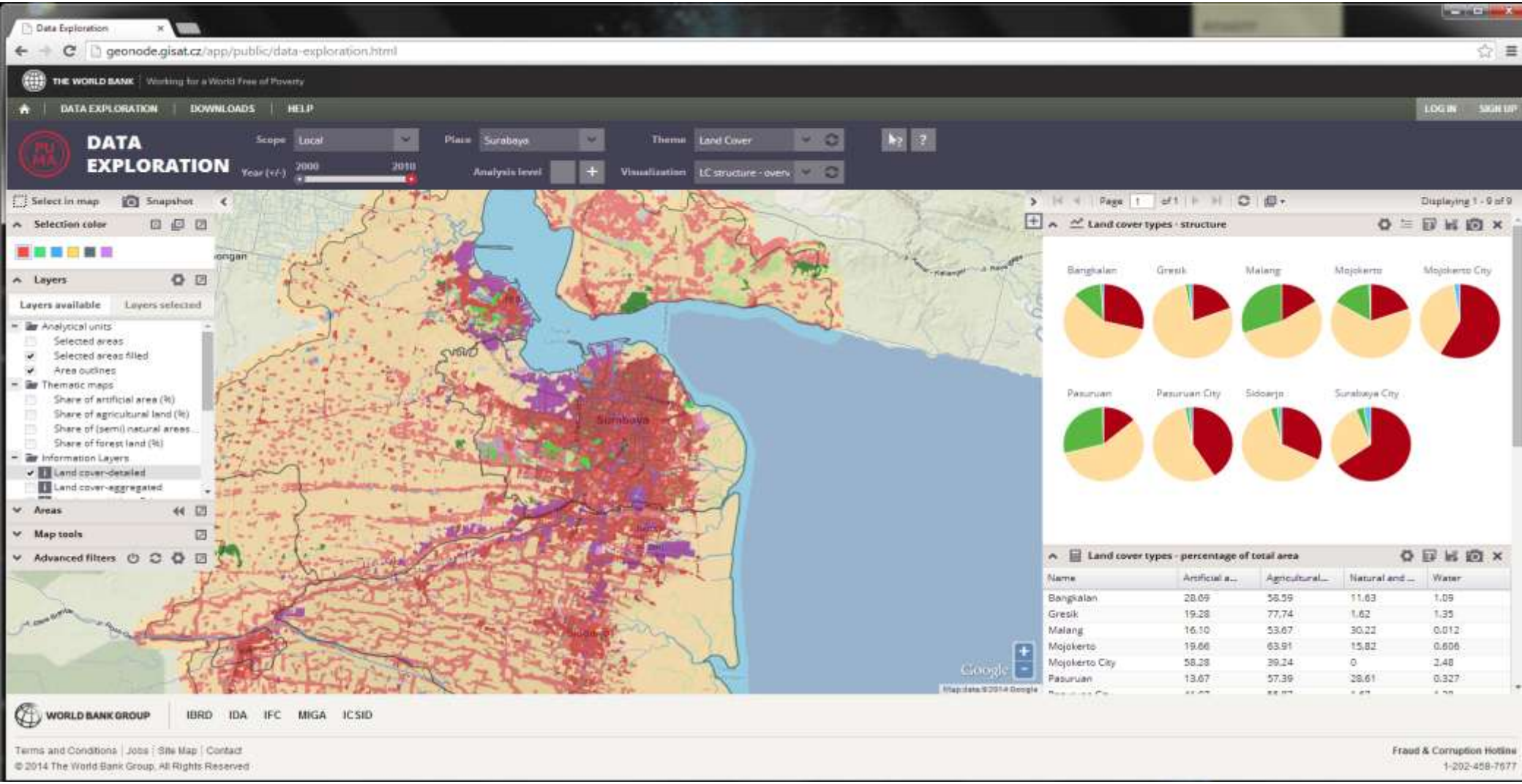
## World Bank EAP Regional Urbanization Flagship // support tool

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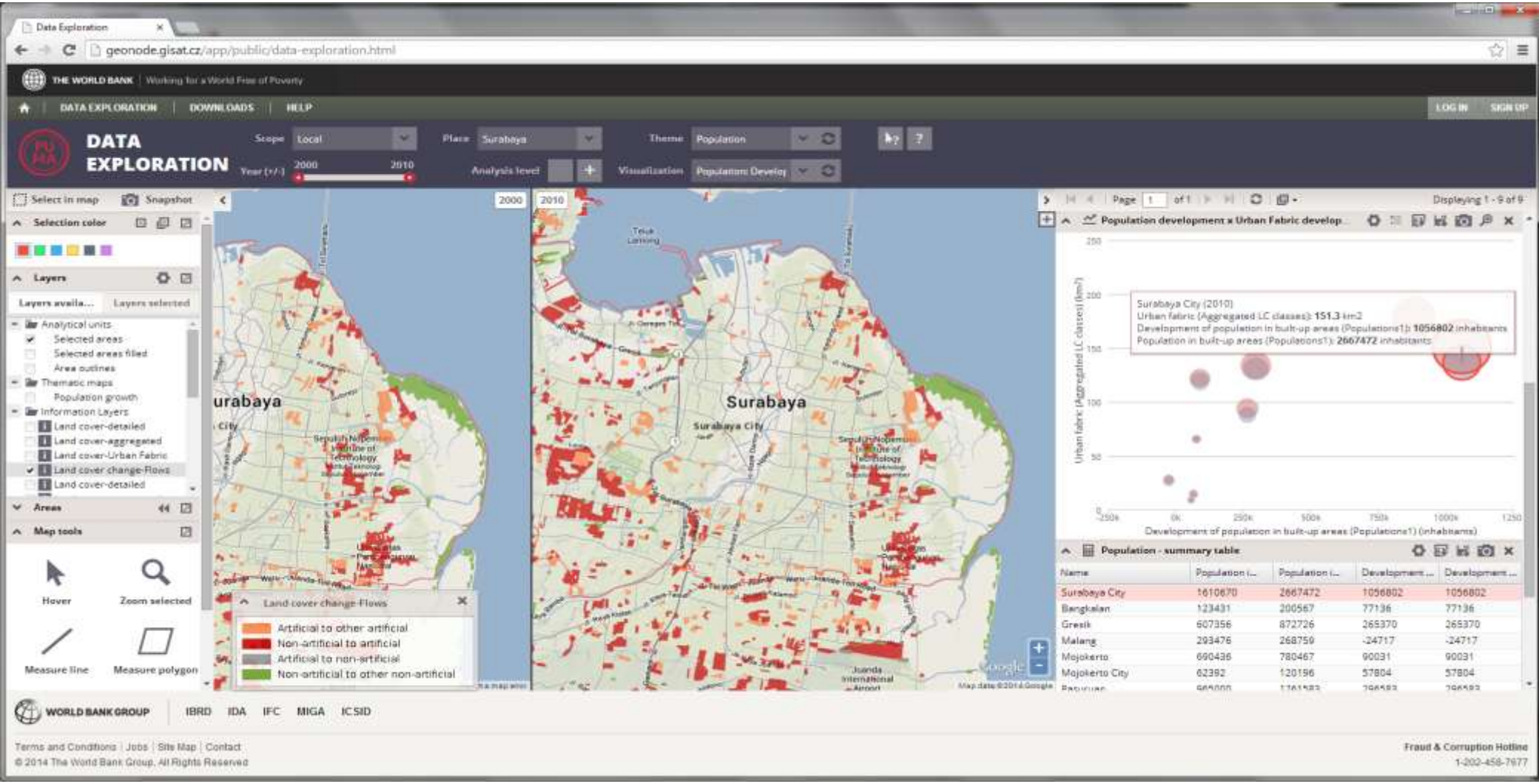


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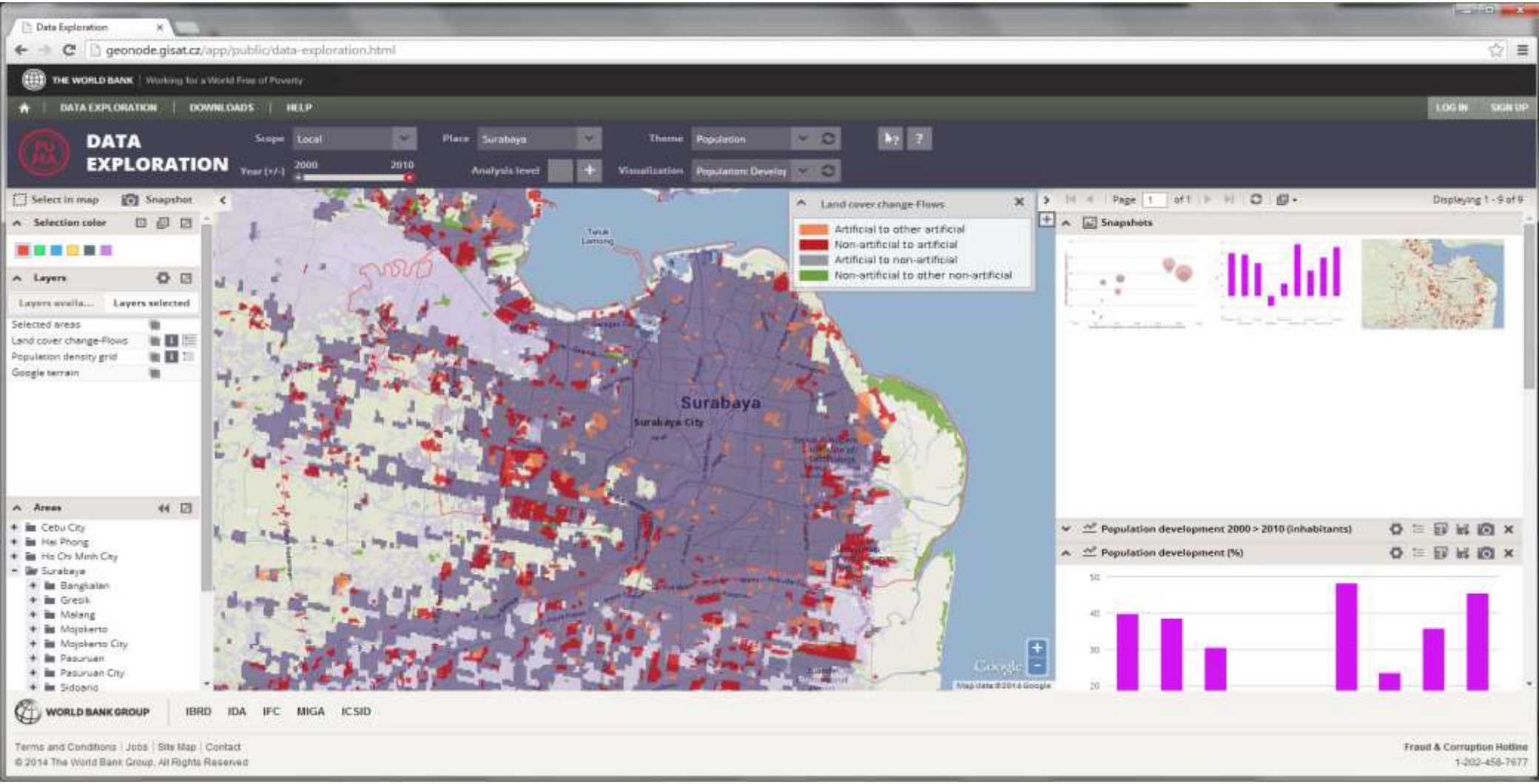


Credit: GISAT for World Bank

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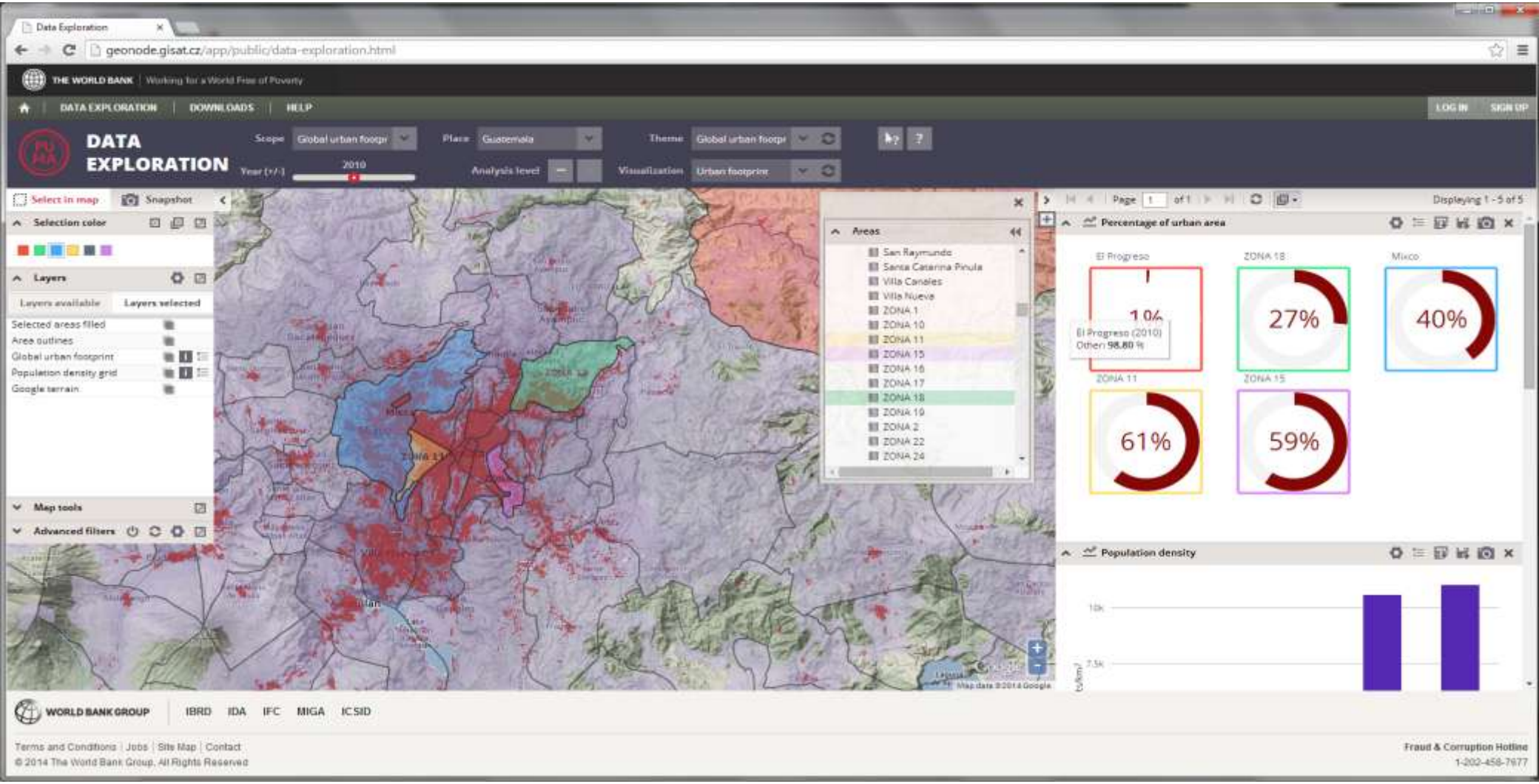


Credit: GISAT for World Bank

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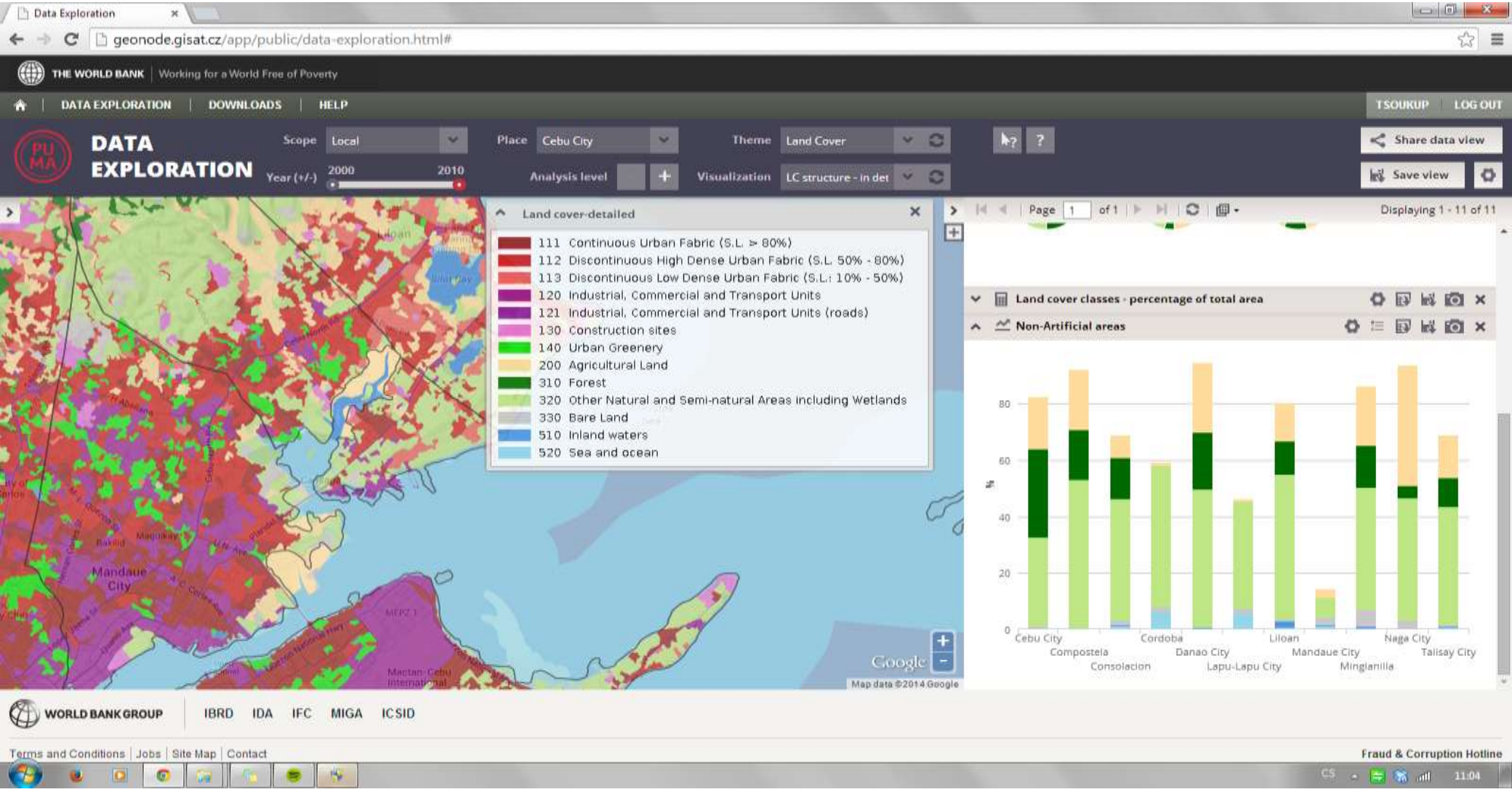
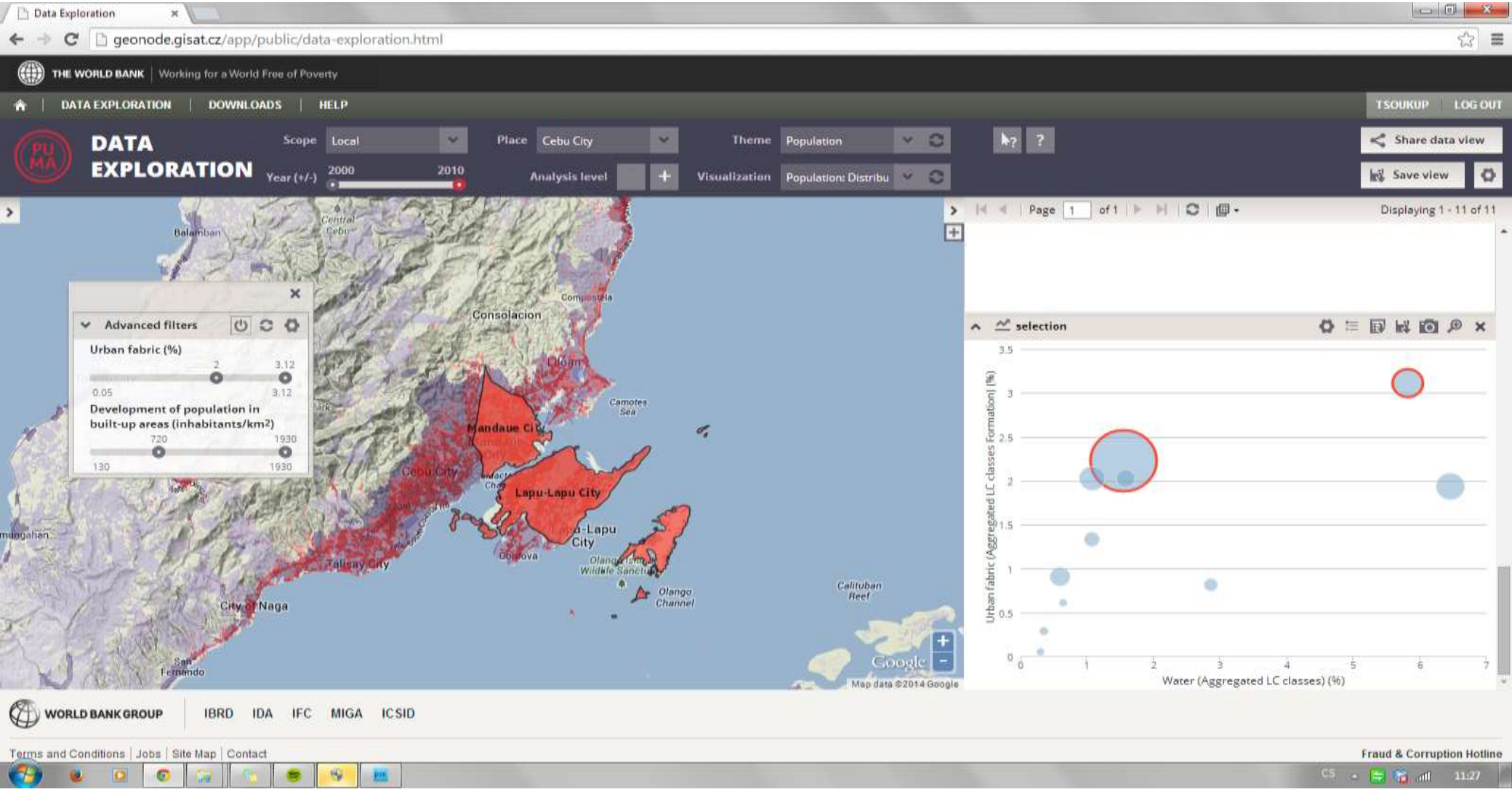



Credit: GISAT for World Bank

# PUMA Examples




Credit: GISAT for World Bank

# Measuring Urban Growth

## Global Urban Unit Data Initiative

- **Phase 1** Creating a Standard Baseline (c.2010) – (completed by end 2015)
  - Urban areas definition (based on adapted OECD Methodology)
  - Urban territorial extent (based on Global Urban Footprint)
  - Population distribution data (based on WorldPop)
  - Updated administrative boundaries dataset (as available)
  - Roll out of the **PUMA Platform** as a WBG urban data hub

- **Phase 2** (2016 - ….)
  - Long term monitoring / historical urban change
    - gathering comparable data from prior years, in order to apply track changes in urban extent from 1990-2000-2010 (combination of various sources of data Global Human Settlements Layer, GUF, nightlights, Modis250, etc.)
    - updates collected in 2015, which will coincide with the new post-2015 Sustainable Development Goals.
    - Looking beyond urban growth: green cities, natural hazards, climate resilience, urban planning and economic perspective, and so on.