

# → EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

## Urban Development

City Academy: Geospatial Data Applications for Urban Development, Sao Paulo 16.-17.09.2019

# Application of Spatial Analytics using EO4SD- Urban products for urban planning

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## Application of spatial analytics using EO4SD-Urban products for urban planning

### Speaker



**Tomas Soukup**

Senior Remote Sensing  
& GIS Consultant  
GISAT, Czech Republic

- Context
  - Urban Development Agenda
  - European Contribution
- Urban Planning and EO Support
- Level of support
- Products and Use Cases examples
- Conclusions
- More Resources



Massive urbanization is a global and challenging trend (especially in the context of climate change)

2.5 billion people i.e. 66% of the global population will live in urban areas by 2050 (UN 2018) so the **Urban Development Agenda** is dominated by:

- Sustainable Urban and Population Growth **Sustainable Development**
- Climate Change **Resilience**



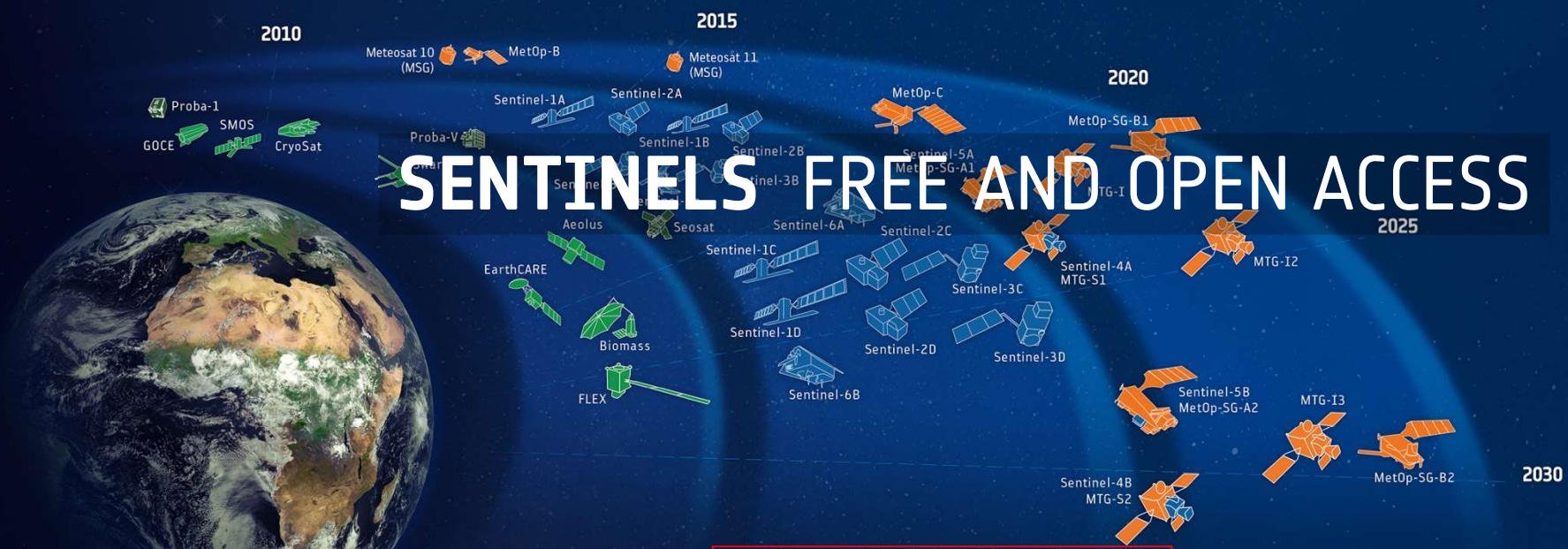
- **Challenge** for governments and city authorities to manage such a growth and provide adequate infrastructure, housing, access to services and safety
- **Opportunity** to drive city on the sustainable development trajectory towards prosperous, green, inclusive and resilient cities



These challenges and opportunities are reflected and embedded in the UN Sustainable Development Goals (SDGs)

ESA EO4SD Urban Project address these challenges by services providing multi-scale dedicated EO based information support

## ESA-DEVELOPED EARTH OBSERVATION MISSIONS



**SENTINELS FREE AND OPEN ACCESS**



Science 

Copernicus 

Meteorology 

[www.esa.int](http://www.esa.int)

European Space Agency

→ EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT  
Urban development








European Space Agency



## SENTINELS



### ESA-DEVELOPED EARTH OBSERVATION MISSIONS

S-1	S-2	S-3	S-4	S-	S-5	S-6
						
Radar	High Res. Optical	Medium Res. Optical & Altimetry	Atmospheric Chemistry (GEO)	Atmospheric Chemistry (LEO)	Atmospheric Chemistry (LEO)	Altimetry
<b>A</b> 3 Apr. 2014	<b>A</b> 23 Jun. 2015	<b>A</b> 16 Feb. 2016	<b>A</b> 2022	<b>A</b> 13 Oct. 2017	<b>A</b> 2021	<b>A</b> 2020
<b>B</b> 25 Apr. 2016	<b>B</b> 6 Mar. 2017	<b>B</b> 25 Apr. 2018	<b>B</b> 2027	<b>B</b> 2027	<b>B</b> 2027	<b>B</b> 2025
<b>C</b> 2022/23	<b>C</b> 2022/23	<b>C</b> 2023		<b>C</b> > 2027		
<b>D</b> > 2022/23	<b>D</b> > 2022/23	<b>D</b> > 2023				



## COPERNICUS IN SUPPORT OF THE UN SUSTAINABLE DEVELOPMENT GOALS

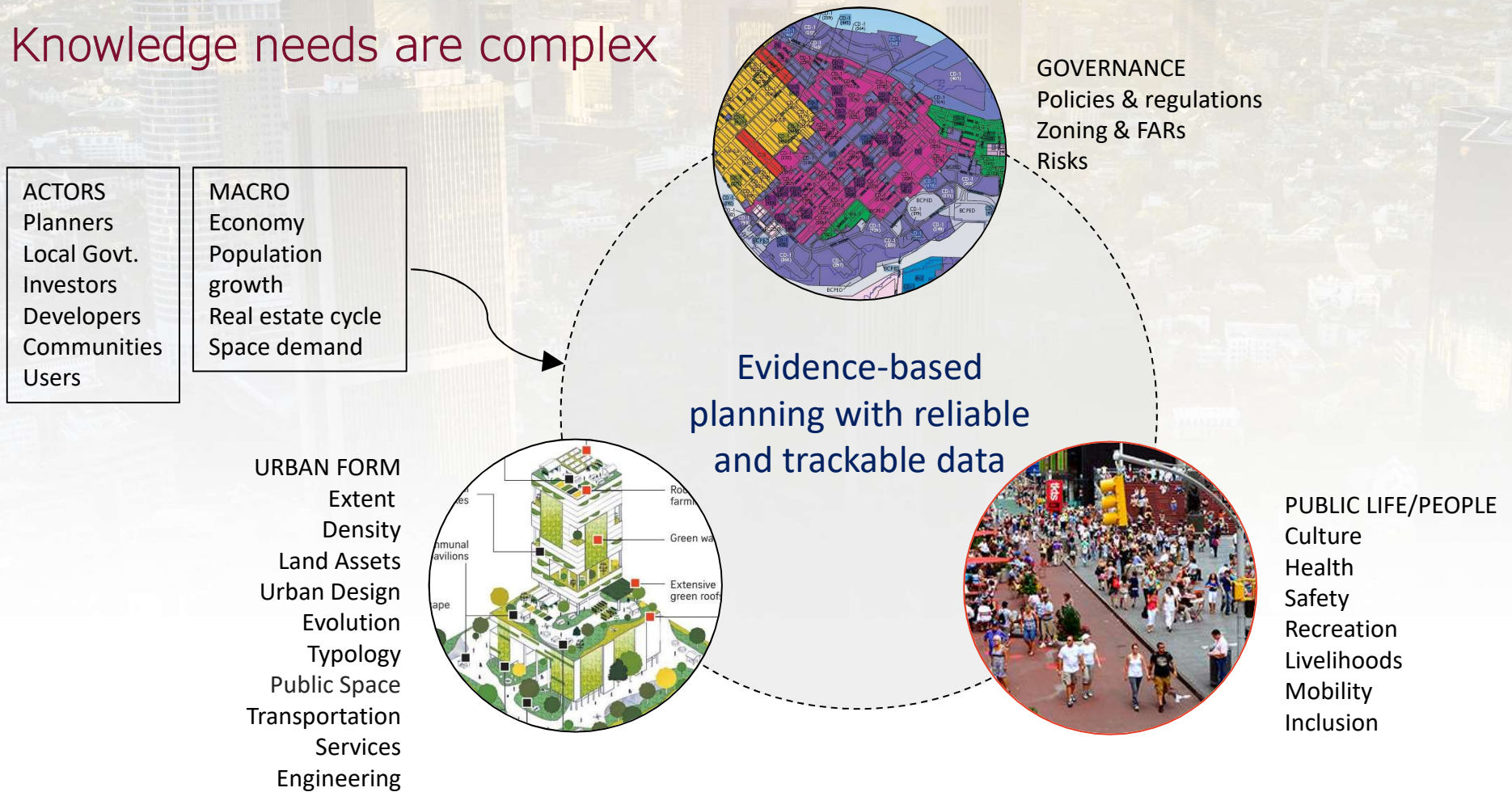
- vital European EO Service Providers Segment  
=> European capacity for support



Regional and urban planning goal is to effectively direct settlement development into high-value, livable, sustainable and resilient structures.

- **highly complex process based on** responsible balancing of advantages and disadvantages from a holistic perspective, taking in account multiple public or private interests.
- the most important condition for the balancing of pro's and con's and a development of strategic orientation for future planning activities is knowledge e.g. **knowledge** on the inhabitants of the city, the physical urban environment, myriads of related processes as well as change over time.

## Knowledge needs are complex

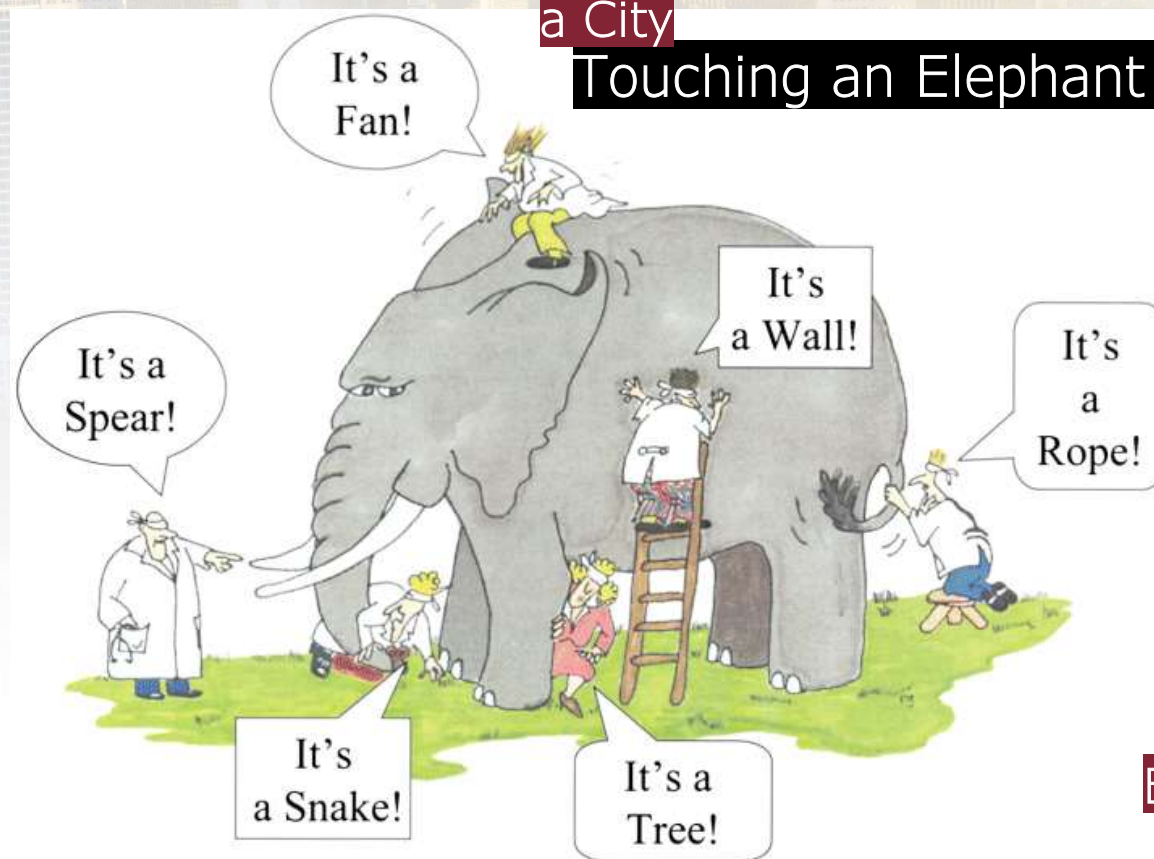




Reality is often simple

a City

## Touching an Elephant with Closing Eyes



Lack of Data

Lack of Resources

Lack of Time

Existing Data in Silos

Urban planners need answers on many space-oriented questions like:

- What defines our city?
- How is the city arranged spatially?
- How dynamic is the urban environment changing over time?
- Where are traffic hot spots?
- How is the life quality in different neighborhoods?
- How many people live there?
- How they access to basic services?

...

Earth Observation has the unique capability to support decision-making with spatial, quantitative data and information products on various topics, from the extraction of urban morphology to the detection of urban growth, surface temperatures, monitoring of traffic, assessment of population with different spatial, temporal and thematic resolution.

# Urban Planning and EO



Potential for EO support is high

Physical accessibility to cities	Urban assets-related Data Availability	Existence of a comprehensive land inventory	
✓	✓	✓	Smart Cities
✓	✓	✗	Middle/high-income cities
✓	✗	✗	Most of WB Client Cities
✗	✗	✗	FCV Cities

Potential for EO support

Extreme potential for EO support



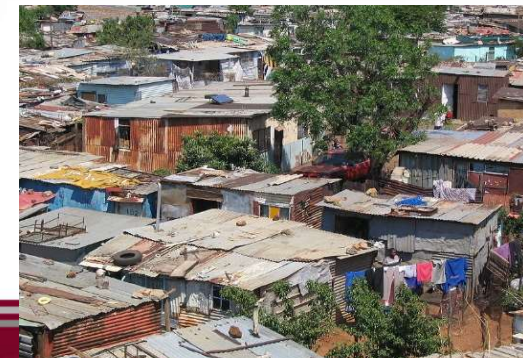
## EO Potential to Support Urban Planning

- Understanding & measuring urban growth
- City global or regional context, benchmarking
- Urban growth dynamic analyses
- Analysis of the effectiveness of Urban Master Plans



- Infrastructure planning (e.g. Road Network Analysis, Accessibility Analysis)

- Assessment and monitoring of informal settlements or slums areas (e.g. EO-based monitoring of unplanned urban sprawl)



## EO Potential for Support for Urban Planning

- Public spaces - urban green and open areas design and planning



- Population distribution and density estimations
- Building heights data for tax estimation

- Hazards, vulnerabilities and risk assessment, disaster management  
e.g. flood risk, land subsidence monitoring





# Support levels of EO4SD-Urban services



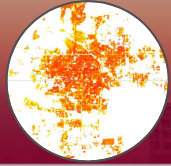
- Strategic
  - Context understanding
  - Long-term assessment
  - Comparison with other cities
  - Potential and risk identification
  - Strategic action prioritization
- Operational
  - Design support
  - Scenario / option prioritization
  - Implementation monitoring
  - Evaluation of impact of actions
  - Reporting





## General city diagnostic

- How much is my city expanding ?
- What is a dynamic of such expansion ?
- What are the trends of such expansion ?
- Where are the areas and axis where it is concentrated ?
- How we are in our city comparing to other cities ?



# Urban Extent (and Change)

## Global products

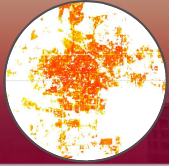


- Amount and distribution of built-up area
- Changes in space and time
- Main axes of development

Urban/Settlement extent is binary information product (built-up or non-built up areas + level of sealing), long time series supported, harmonized

- Global or regional benchmarking
- Development plan monitoring
- Transport and services actions prioritization
- Run-off and flood modelling (sealing)

← global ————— local →

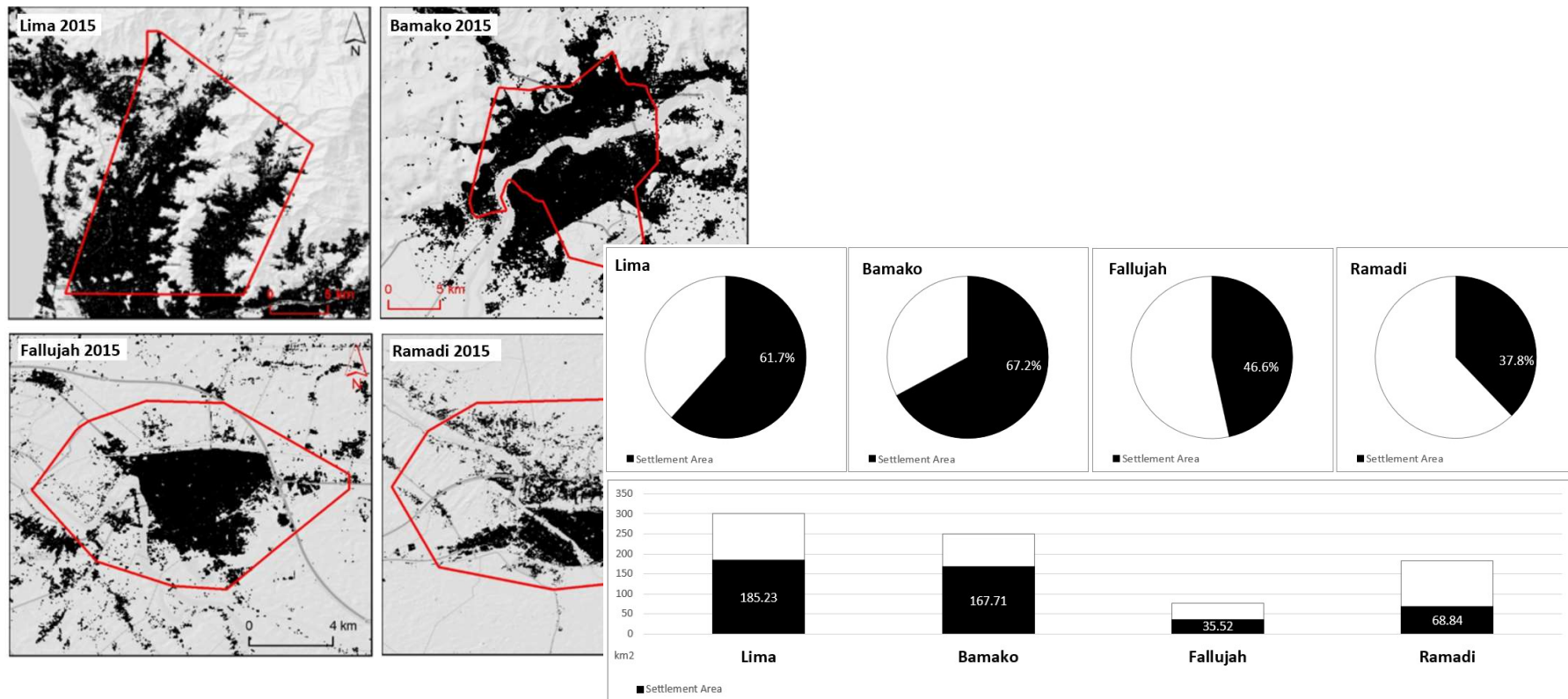


# Urban Extent (and Change)

## Global products



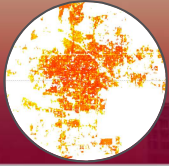
- Amount and distribution of built-up area



← global

→ local →



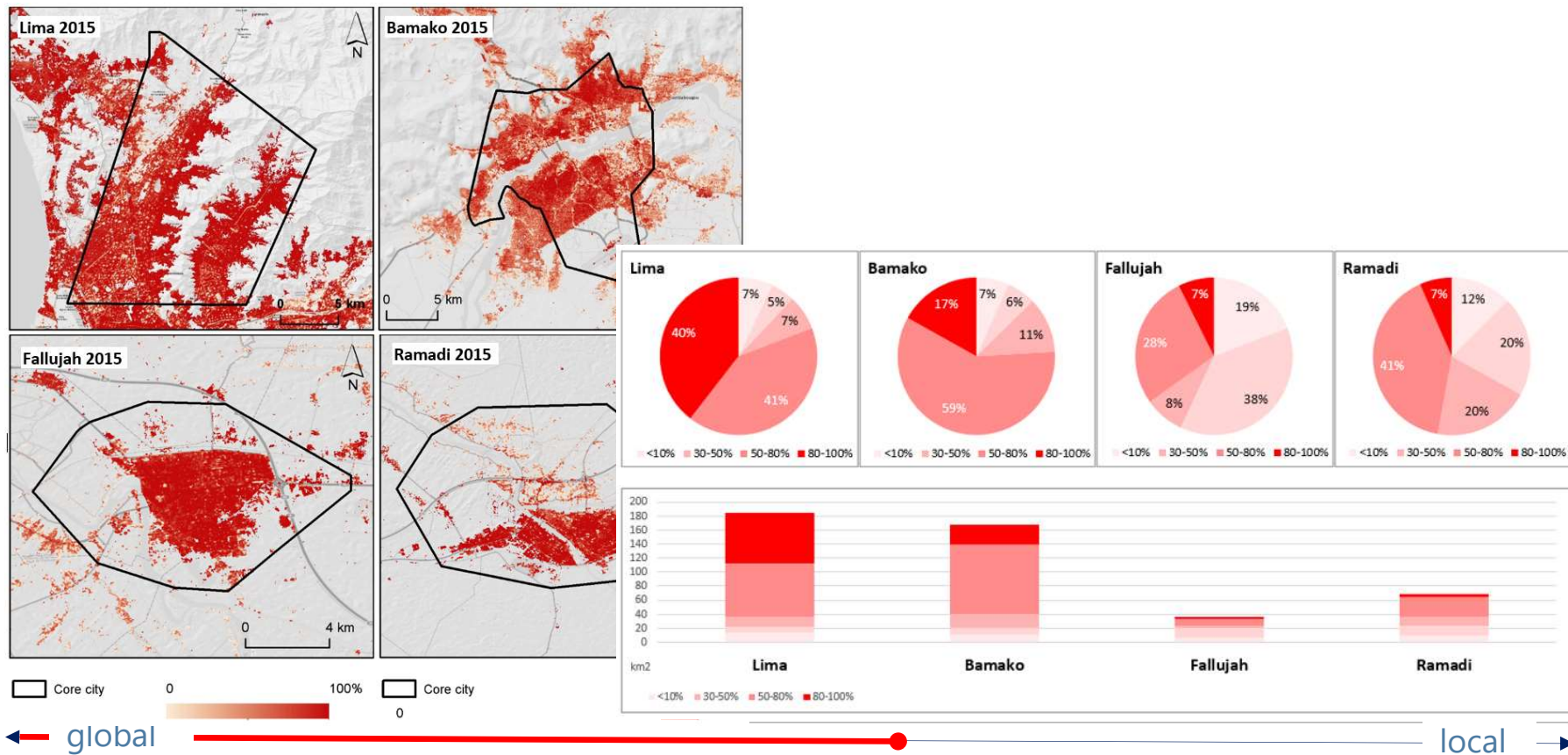


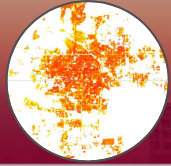
# Urban Extent (and Change)

## Global products



- Amount and distribution of built-up area (sealing level)





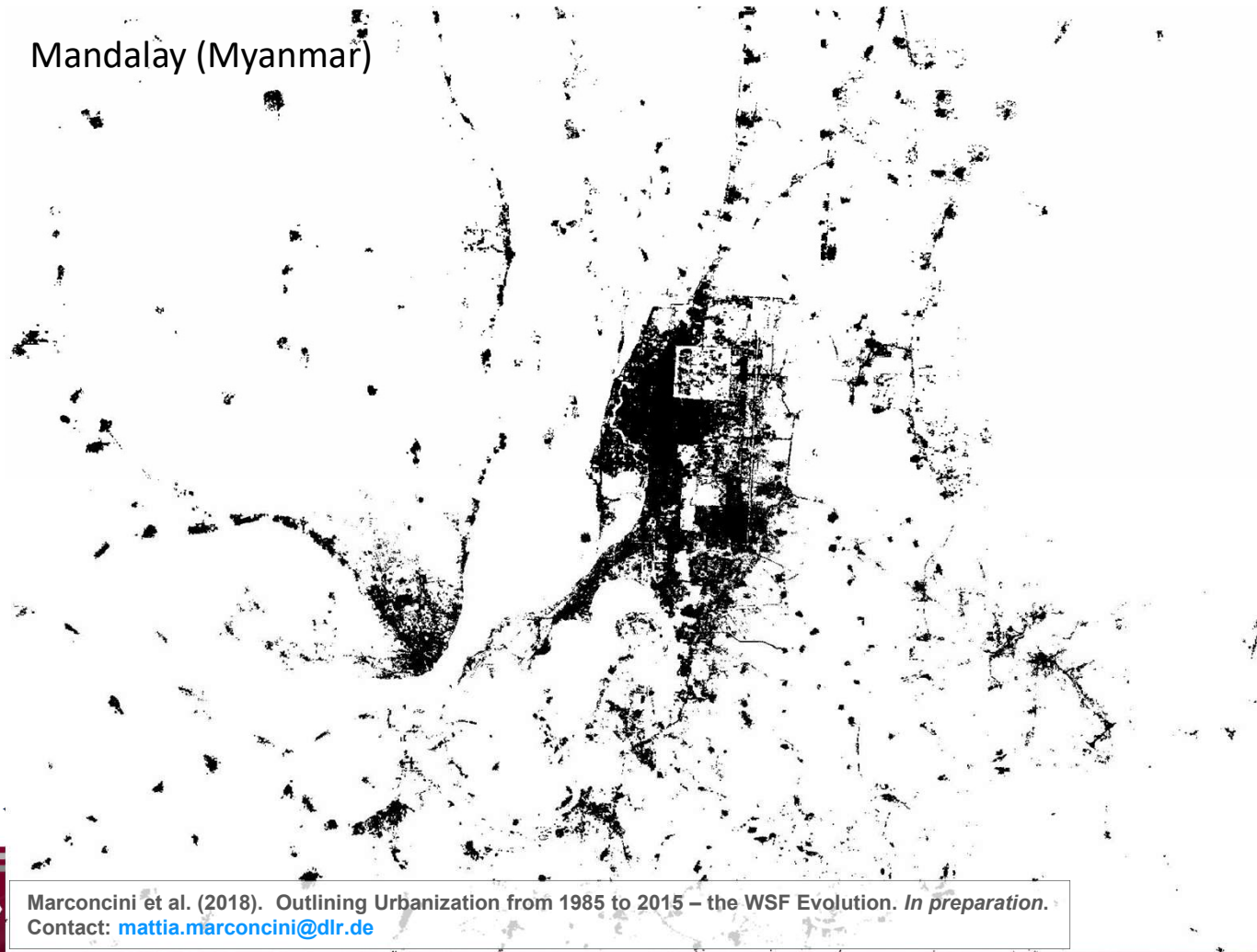
# Urban Extent (and Change)

## Global products



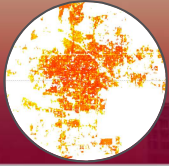
- Changes in space and time, axes of development

Mandalay (Myanmar)



Marconcini et al. (2018). Outlining Urbanization from 1985 to 2015 – the WSF Evolution. *In preparation.*  
Contact: [mattia.marconcini@dlr.de](mailto:mattia.marconcini@dlr.de)





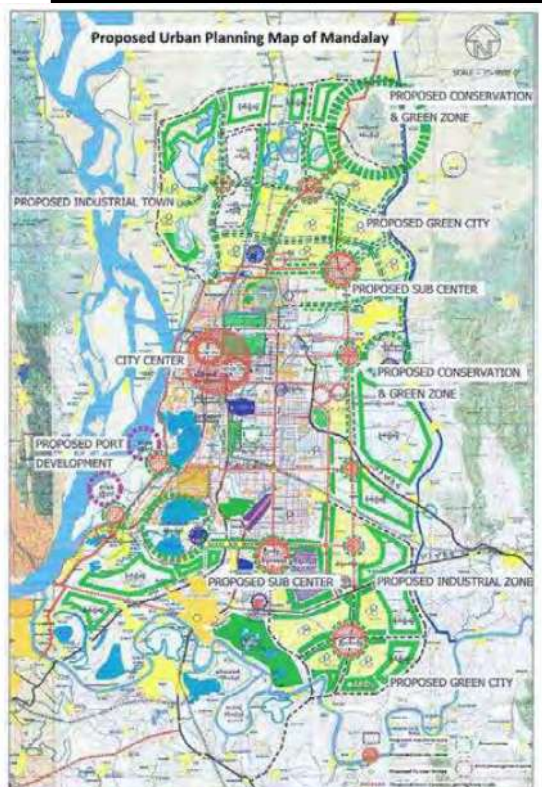
# Urban Extent (and Change)

## Global products

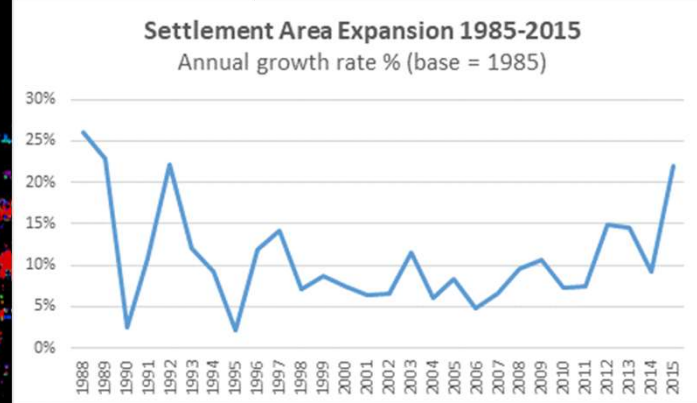
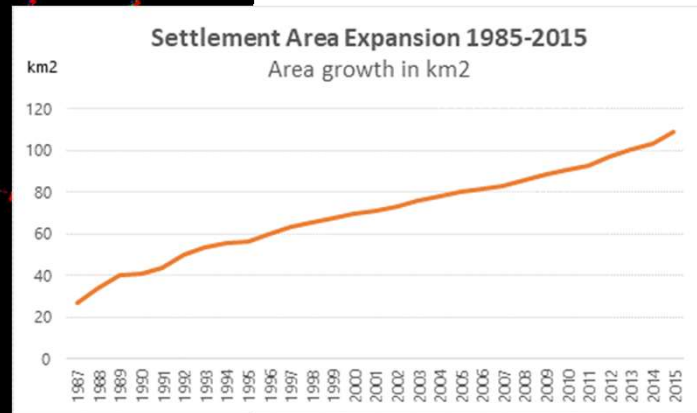
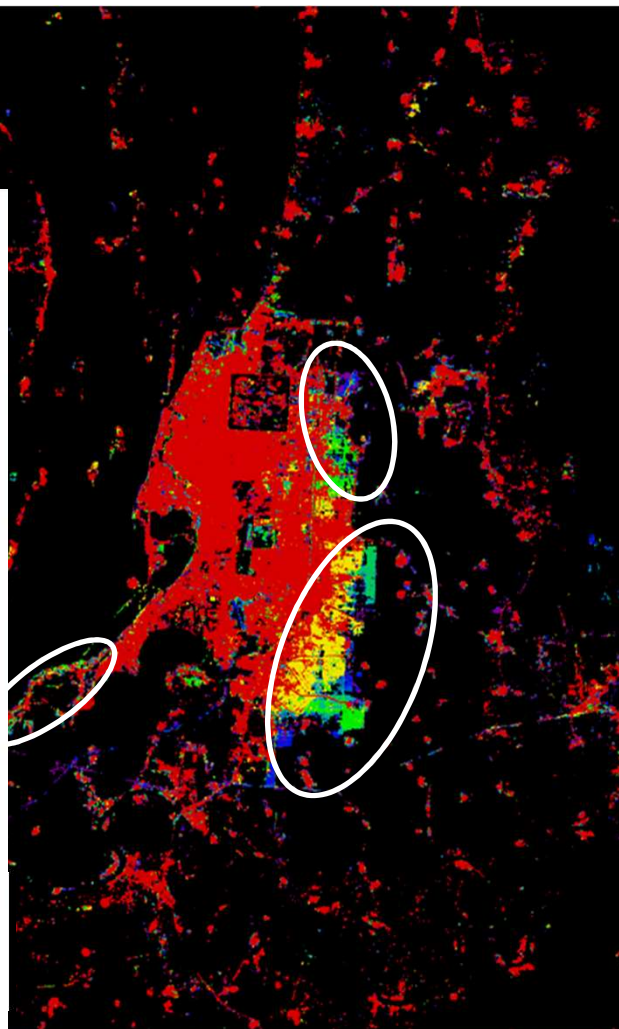


- Changes in space and time, axes of development

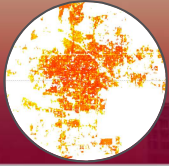
### Mandalay (Myanmar)



Source: Mandalay Urban Development Conceptual Plan, MOC





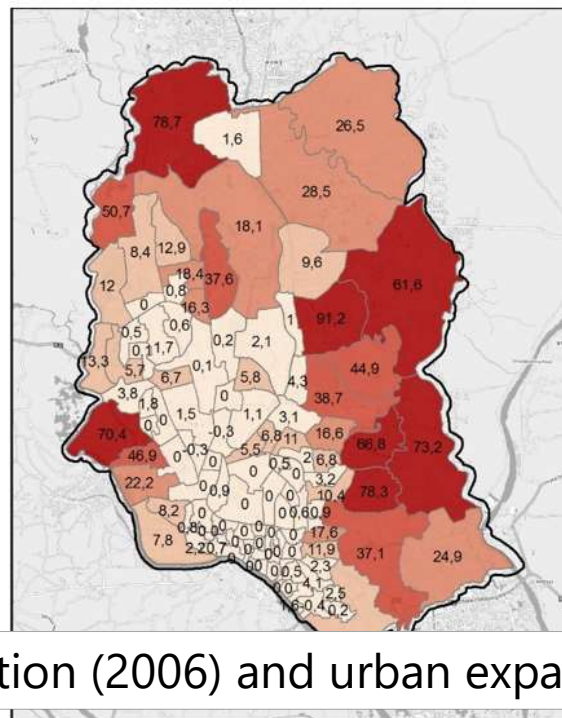
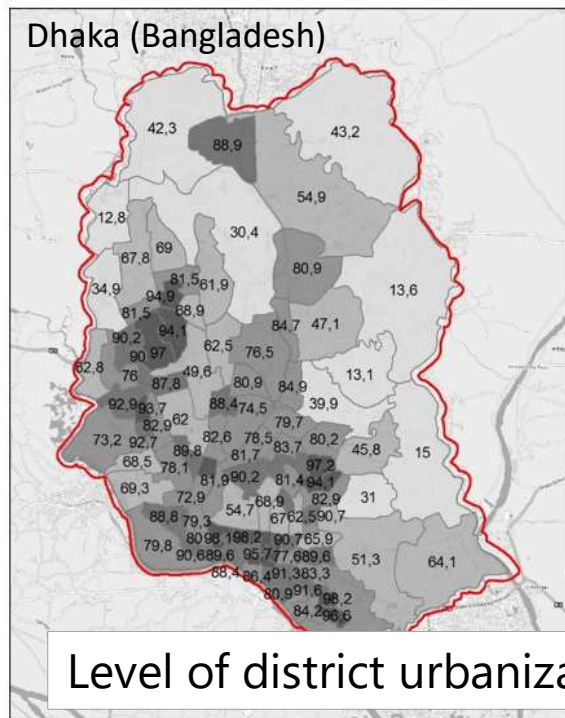


# Urban Extent (and Change)

## Global products



- Changes in space and time, axes of development



Level of district urbanization (2006) and urban expansion intensity 2006-2017

Core City



Core City

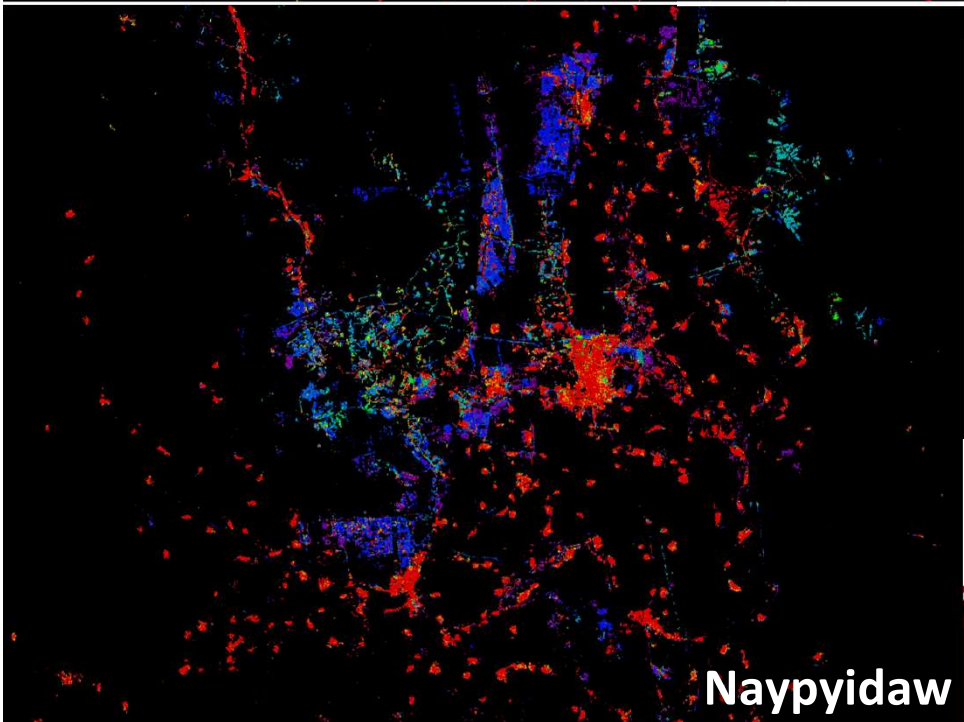
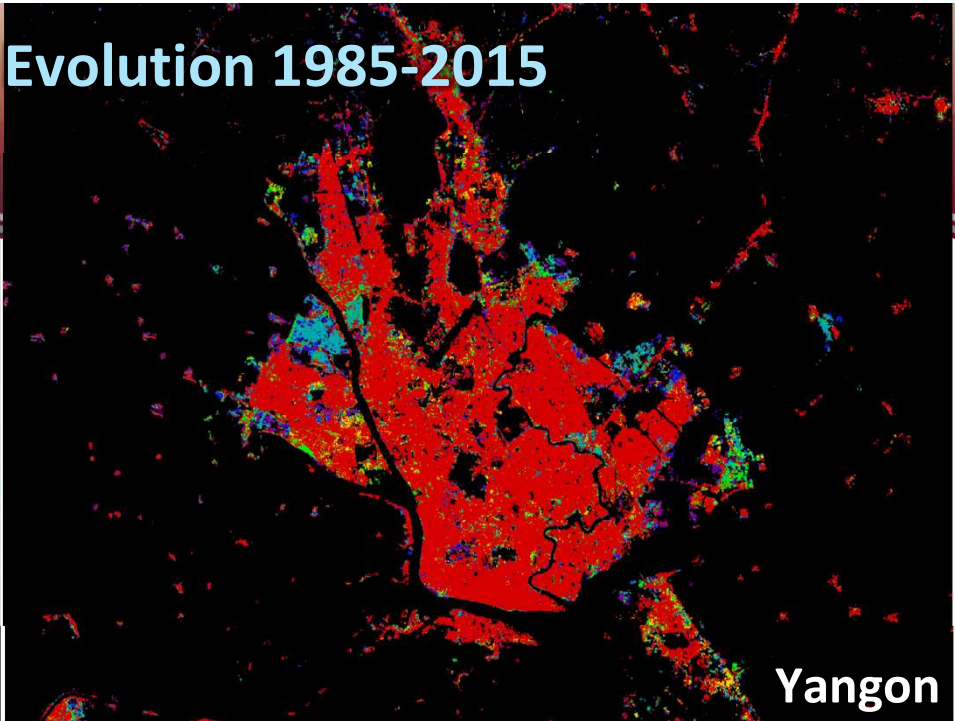
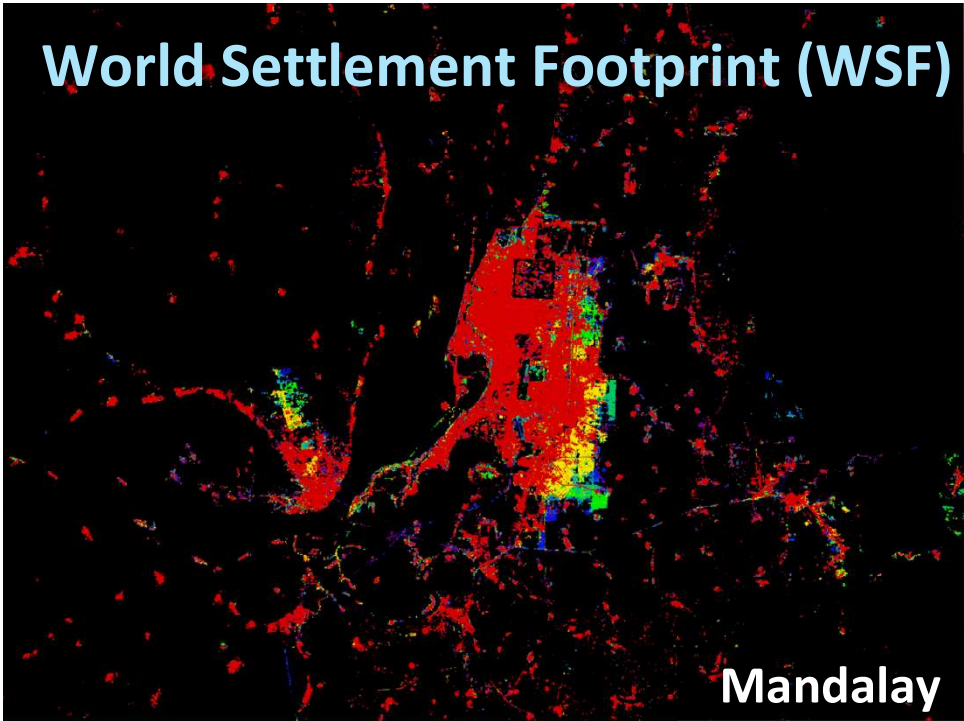


← global



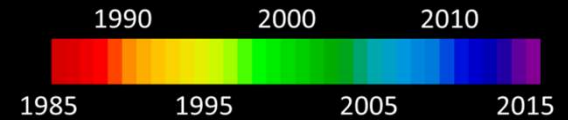
local →

# World Settlement Footprint (WSF) Evolution 1985-2015



## Legend

Reference years

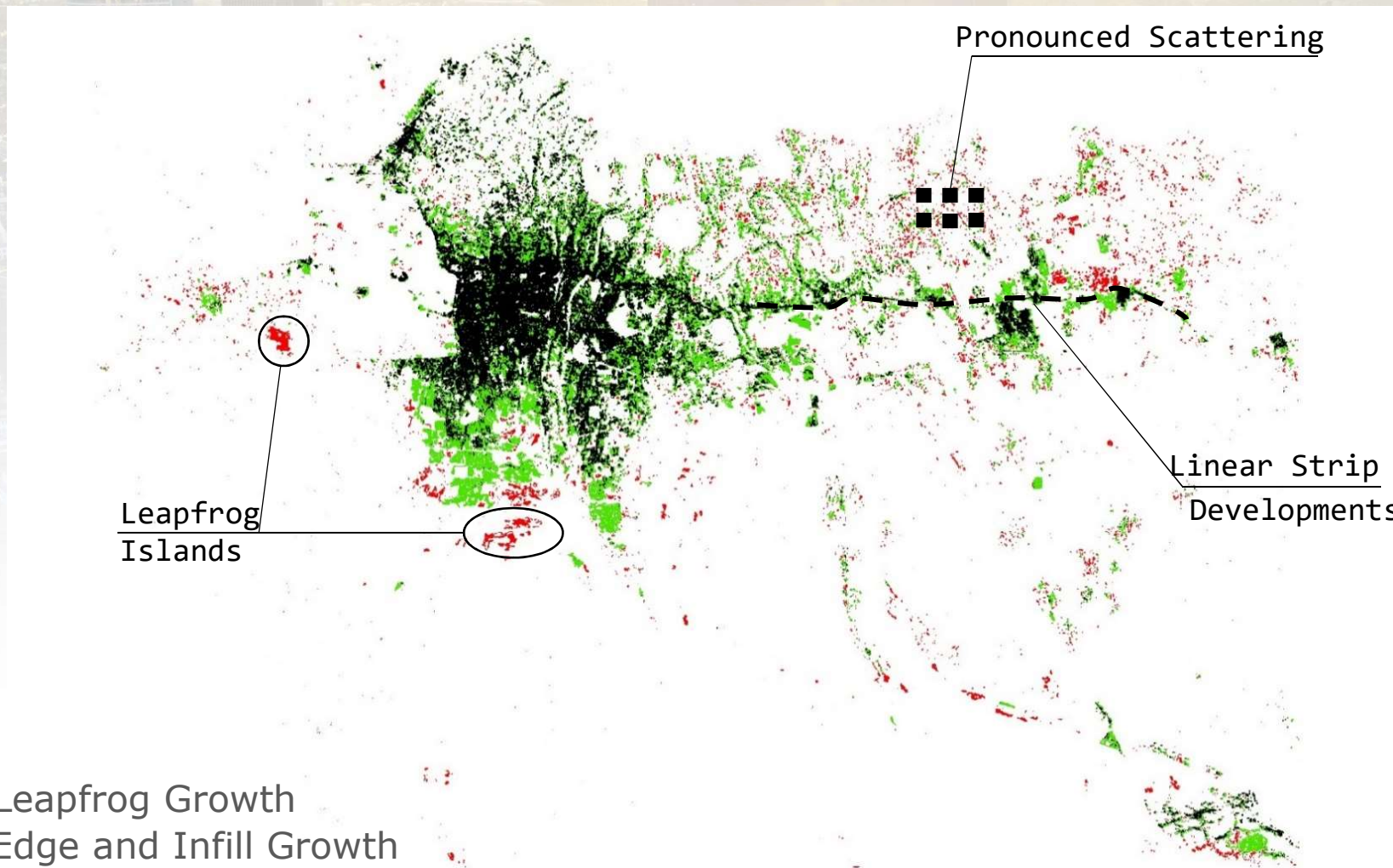


Global WSF Evolution data  
freely available Q1/2020  
via [www.urban-tep.eu](http://www.urban-tep.eu)

Marconcini et al. (2018). Outlining Urbanization from 1985 to 2015 – the WSF Evolution. *In preparation*.  
Contact: [mattia.marconcini@dlr.de](mailto:mattia.marconcini@dlr.de)

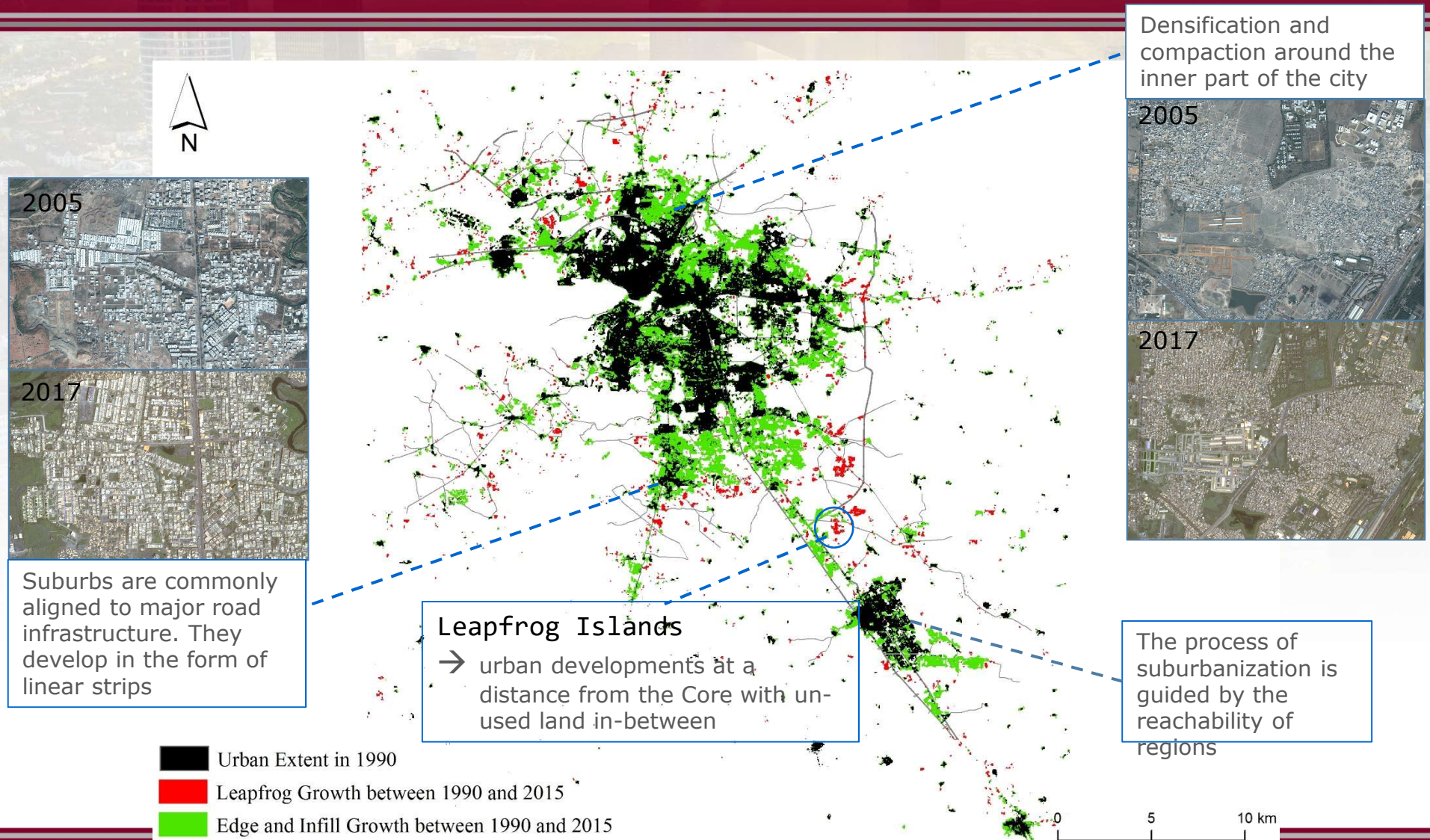


# Urban Growth Patterns in Arusha City (2000 – 2015)



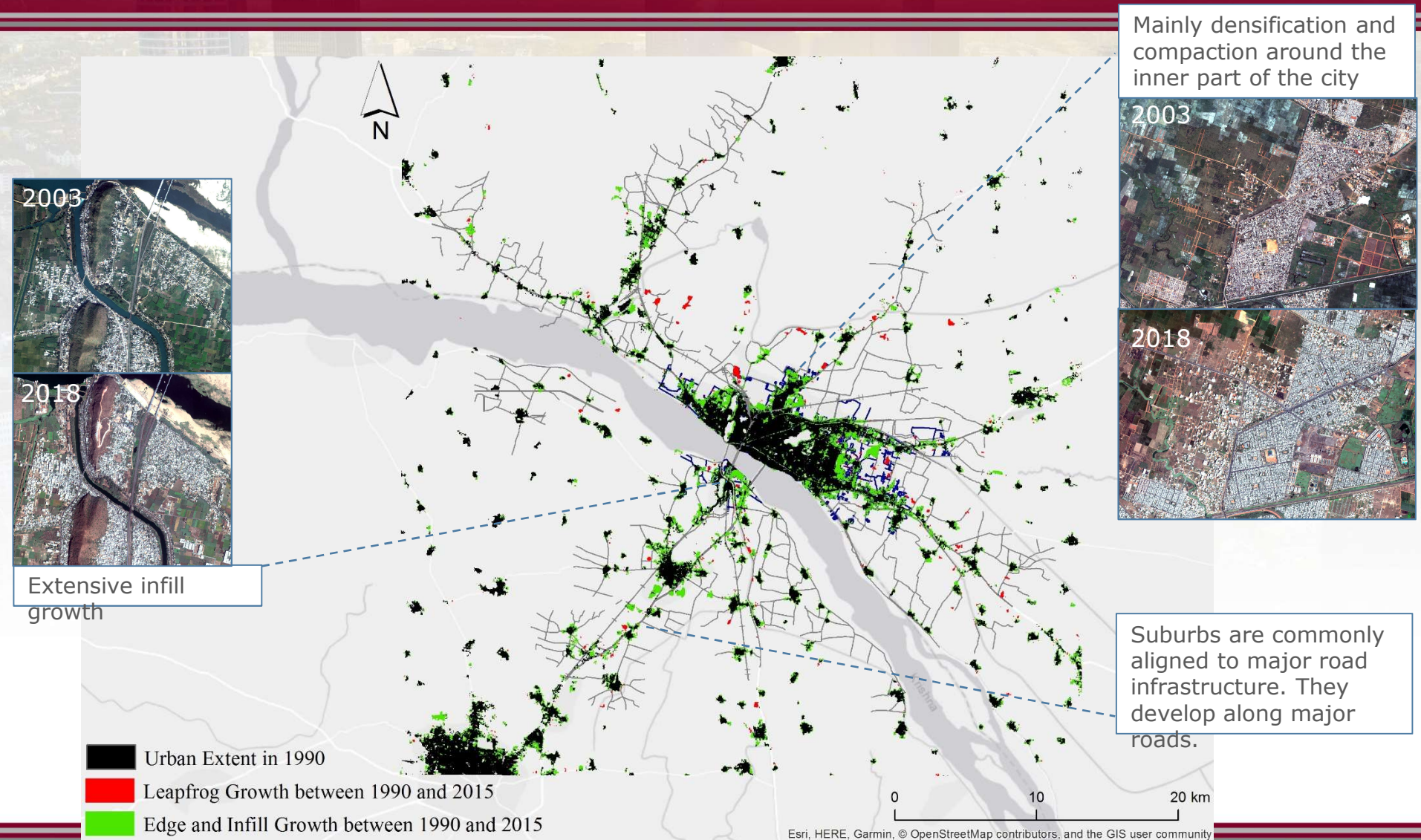


# Bhopal: Urban Growth between 1990 – 2015

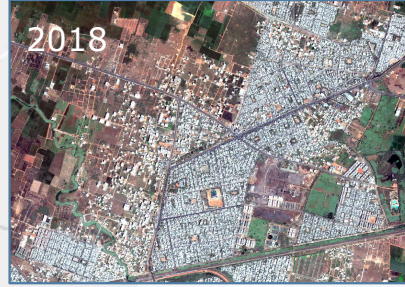
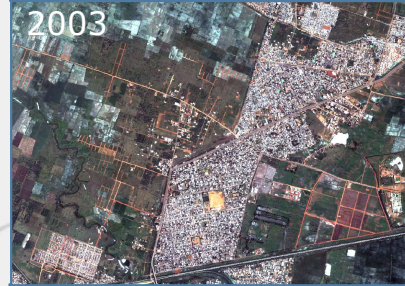




# Vijayawada: Urban Growth between 1990 – 2015



Mainly densification and compaction around the inner part of the city

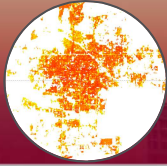


Suburbs are commonly aligned to major road infrastructure. They develop along major roads.

Extensive infill growth

- Urban Extent in 1990
- Leapfrog Growth between 1990 and 2015
- Edge and Infill Growth between 1990 and 2015

Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community



# Urban Extent (and Change) Global products



GLOBAL URBAN GROWTH GREEN AREAS LAND ASSETS STRUCTURE

## Global Urban Growth Dynamics Monitoring

Earth Observation data can provide unprecedented insight into long term trends in urban growth dynamics globally

The urbanized World is our playground. Facing global massive urbanization trends in climate change context, urban expansion needs to be monitored to ensure it proceeds on a sustainable basis, does not impair or overexploit environmental resources, nor worsen the quality and life and safety of the urban population. Nowadays, EO based global products are available for urban studies to be done in rich spatial-temporal context, quickly and accurately.

Settlement Area Expansion (1985-2015)

Tianjin

Dakar

Legend:

- 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, No data

### Settlement Area Expansion (area growth in km<sup>2</sup>)

Maximum settlement area (km<sup>2</sup>) displayed:  Full range  2000 km<sup>2</sup>  500 km<sup>2</sup>

The documentation of urban expansion over time can reveal different phases of urbanisation as illustrated above - early growth period, slow or rapid expansion, acceleration or saturation. Information about the expansion phase and its dynamics are important to cluster cities with similar evolution path and support lesson-learned exchange between individual cities.

### Settlement Area Expansion (annual growth rate in %)

Maximum settlement area growth rate (%) displayed:  Full range  15%  5%

Similarly, urban expansion rate over time can be also compared between different cities as illustrated above to explore development trajectories in the context of existing urban policy framework in particular city and time.

### Urban Expansion Coefficient

As EO4SD-Urban contribution to the GPSC's 3<sup>rd</sup> Global Meeting Urban Growth Dynamics Monitoring Storyline for all GPSC Cities is available at <https://urban-tep.eu/visat/scudeoStories19/globalWsfu>



## Land Assets Management (incl. Risk Management)

- What are land assets in my city ?
- Are they in optimal composition and quantity / quality ?
- Are they in risk?
- How they evolve ? As planned ? Formal/Informal?
- Are there trends of their change ? Positive or negative ?
- Which actions to take to improve ?
- Where are the hotspot ?
- Which option or scenario to follow ?
- How we perform ?
- How we are in our city comparing to other cities ?



# (Peri-) Urban Land Cover / Land Use

## Regional and Detailed Products



- Land cover / land use composition in wider context
- Quantity and quality of changes and land flows
- Support to assessment of main processes behind changes

Urban & Peri-Urban Land Cover and Land Use are categorical products classified into standard nomenclature of land cover and land use classes, HR/VHR resolution, long-time series supported, harmonized

- Land Assets Management
- Risk Management
- Detailed development plan assessment
- Green and Public Spaces monitoring
- Prioritization of development focus
- Population and services access modelling

← global

local →



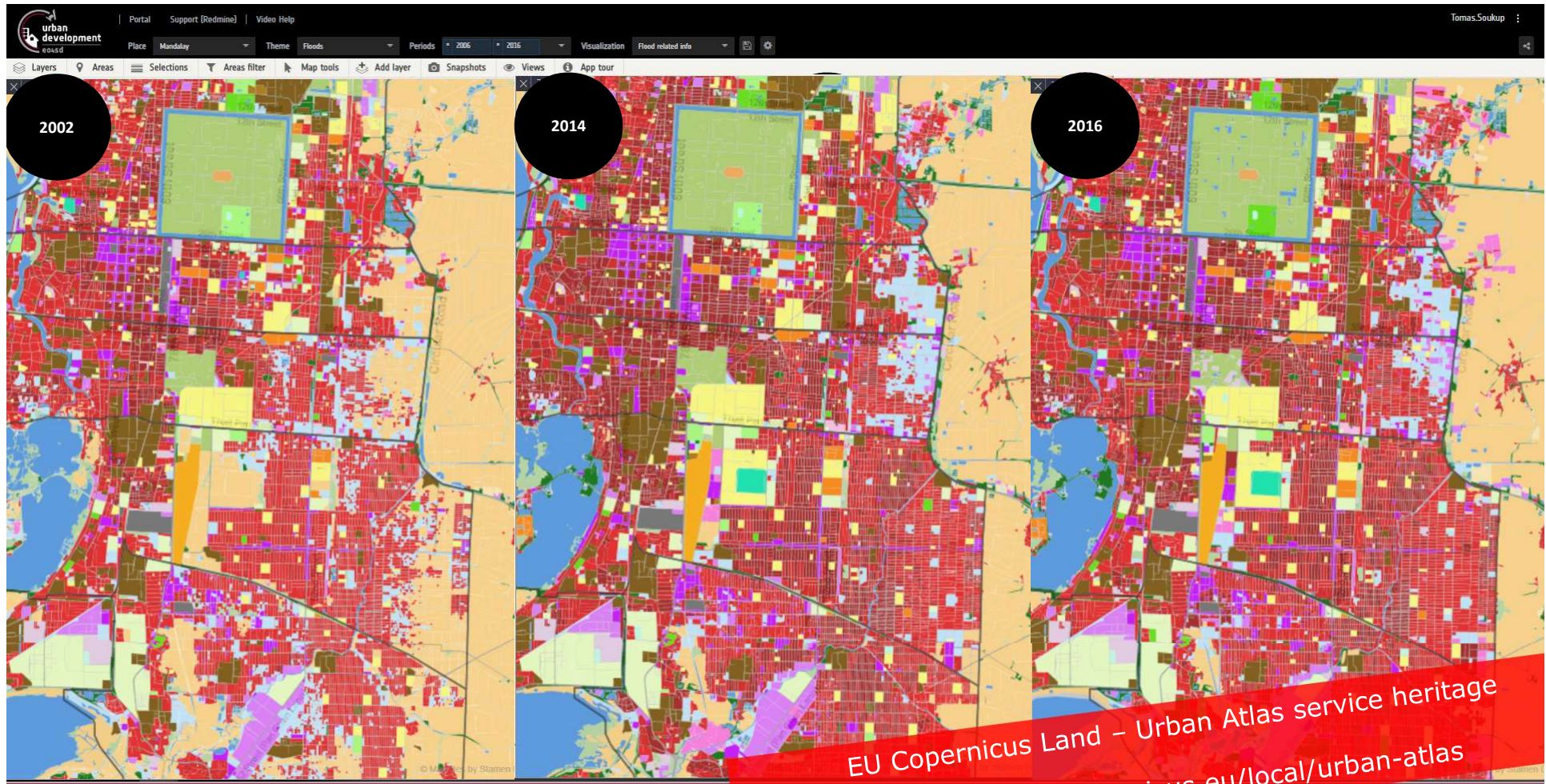


# (Peri-) Urban Land Cover / Land Use

## Regional and Detailed Products



Time series – ideally in line with planning cycles







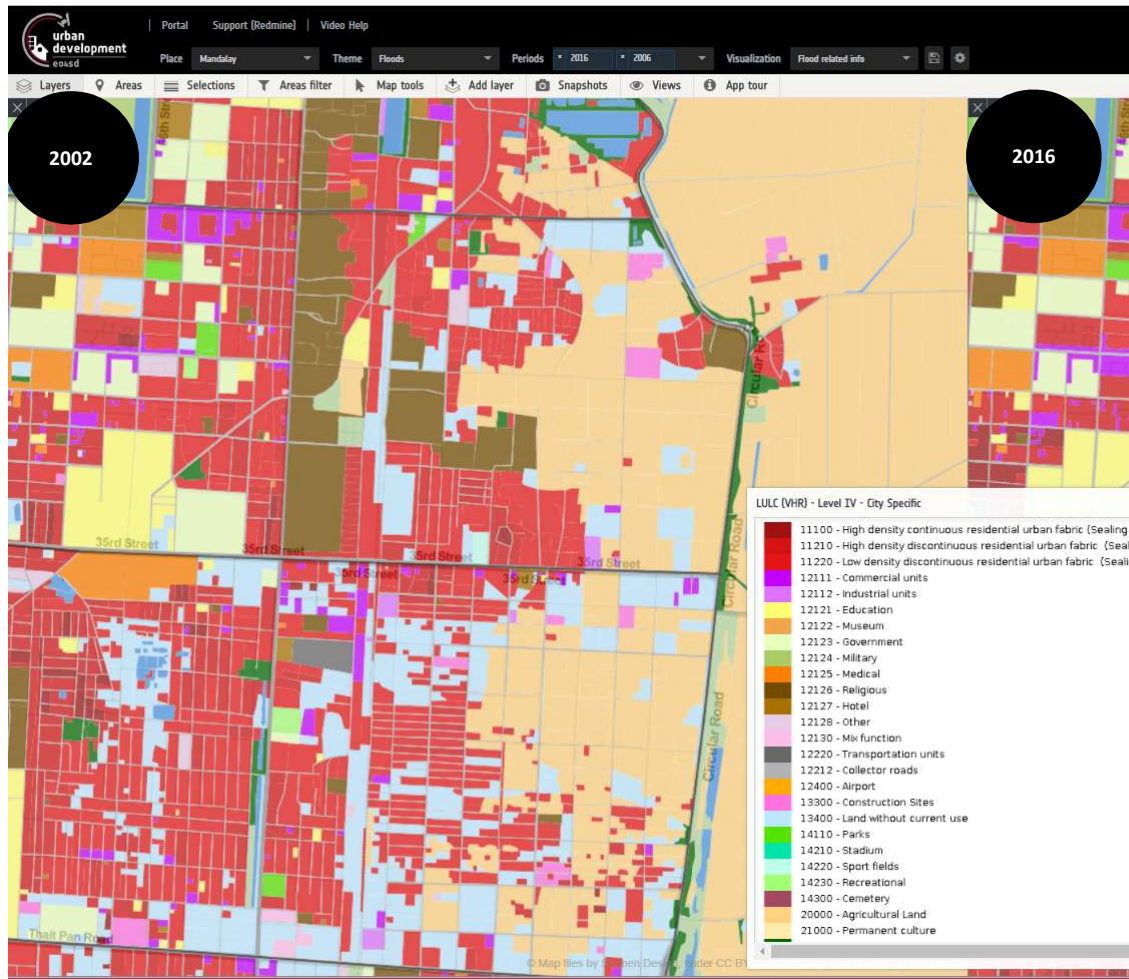
# (Peri-) Urban Land Cover / Land Use

## Regional and Detailed Products



### Standard nomenclature

### Land Cover Land Use Nomenclature (LCLU)



LULC Level I	LULC Level II	LULC Level III
Artificial surfaces	Urban Fabric	Continuous Urban Fabric (Sealing Layer-SL > 80%)
		Discontinuous Dense Urban Fabric (S.L. 50% - 80%)
		Discontinuous Low Density Urban Fabric (S.L. 10% - 50%)
	Industrial, commercial, public, military, private and transport unit	Industrial and commercial units
		Non-residential urban fabric
		Road and rail network and associated land (Open Street Map) Airport areas
Urban greenery	Urban green	
	Sport and leisure facilities	
Construction and other sites	Construction sites	
	Land without current use	
Non-artificial surface	Agriculture land	
	Forest	
	Natural and semi-natural land including wetlands	
	Bare land	
	Water bodies	





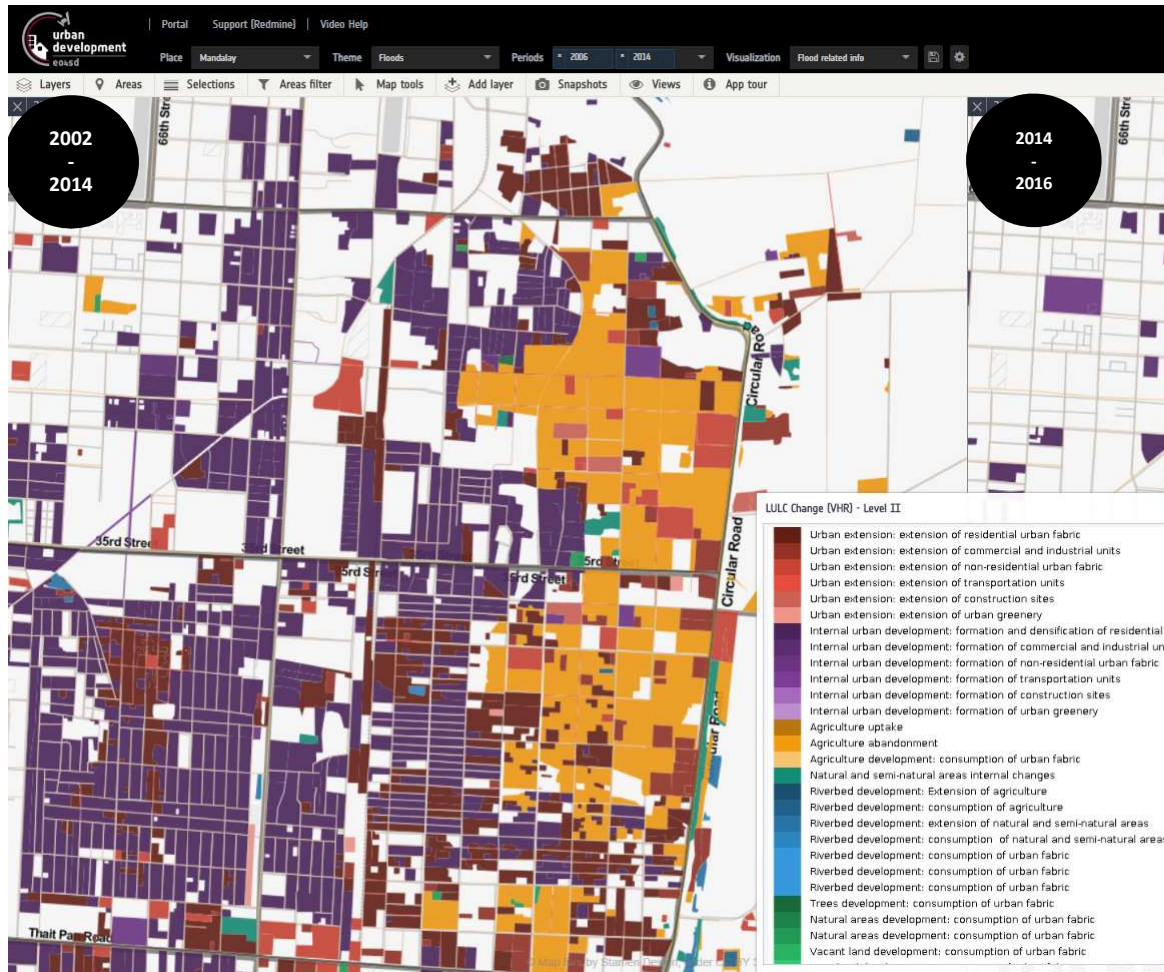
# (Peri-) Urban Land Cover / Land Use

## Regional and Detailed Products



### Standard definition of flows

### Land Cover Flows (LCF)



LCF level 1	LCF level 2	Description
LCF10: Urban extension	LCF11: Urban extension: extension of residential urban fabric	Formation of new residential urban fabric over non-artificial land over non-artificial land
	LCF12: Urban extension: extension of commercial & industrial units	Formation of new commercial & industrial fabric over non-artificial land
	LCF13: Urban extension: extension of transportation units	Formation of new transportation units over non-artificial land
	LCF14: Urban extension: extension of non-residential urban fabric	Formation of new non-residential urban fabric over non-artificial land over non-artificial land
	LCF15: Urban extension: extension of urban greenery	Formation of new urban greenery areas over non-artificial land
	LCF16: Urban extension: extension of construction sites	Formation of new construction sites over non-artificial land
LCF20: Urban internal changes	LCF21: Internal urban development: formation and densification of residential urban fabric	Internal conversion between artificial surfaces, formation and densification of residential urban fabric over other urban classes
	LCF22: Internal urban development: formation of commercial & industrial units	Internal conversion between artificial surfaces, formation of commercial and industrial units over other urban classes
	LCF23: Internal urban development: formation of transportation units	Internal conversion between artificial surfaces, formation of transportation units over other urban classes
	LCF24: Internal urban development: formation of non-residential urban fabric	Internal conversion between artificial surfaces, formation of non-residential urban fabric over other urban classes
	LCF25: Internal urban development: formation of urban greenery	Internal conversion between artificial surfaces, formation of urban greenery over other urban classes
	LCF26: Internal urban development: formation of construction sites	Internal conversion between artificial surfaces, formation of construction sites over other urban classes
LCF30: Agriculture development	LCF31: Agriculture uptake	Conversion of various types of natural and semi-natural land into agricultural land
	LCF32: Agriculture abandonment	Abandonment of agricultural land in favor of various types of natural and semi-natural land
	LCF33: Agriculture development: consumption of urban fabric	Conversion of various types of urban fabric into agricultural land
LCF40: Natural and semi-natural internal changes	LCF40: Natural and semi-natural areas internal changes	Internal conversion between various natural and semi-natural classes
LCF50: Riverbed and water bodies development	LCF51: Riverbed development: Extension of agriculture	Conversion of water body into agriculture (related mostly to riverbed development)
	LCF52: Riverbed development: consumption of urban fabric	Conversion of agriculture into water body (related mostly to riverbed development)
	LCF53: Riverbed development: extension of natural and semi-natural areas	Conversion of water body into natural and semi-natural land (related mostly to riverbed development)



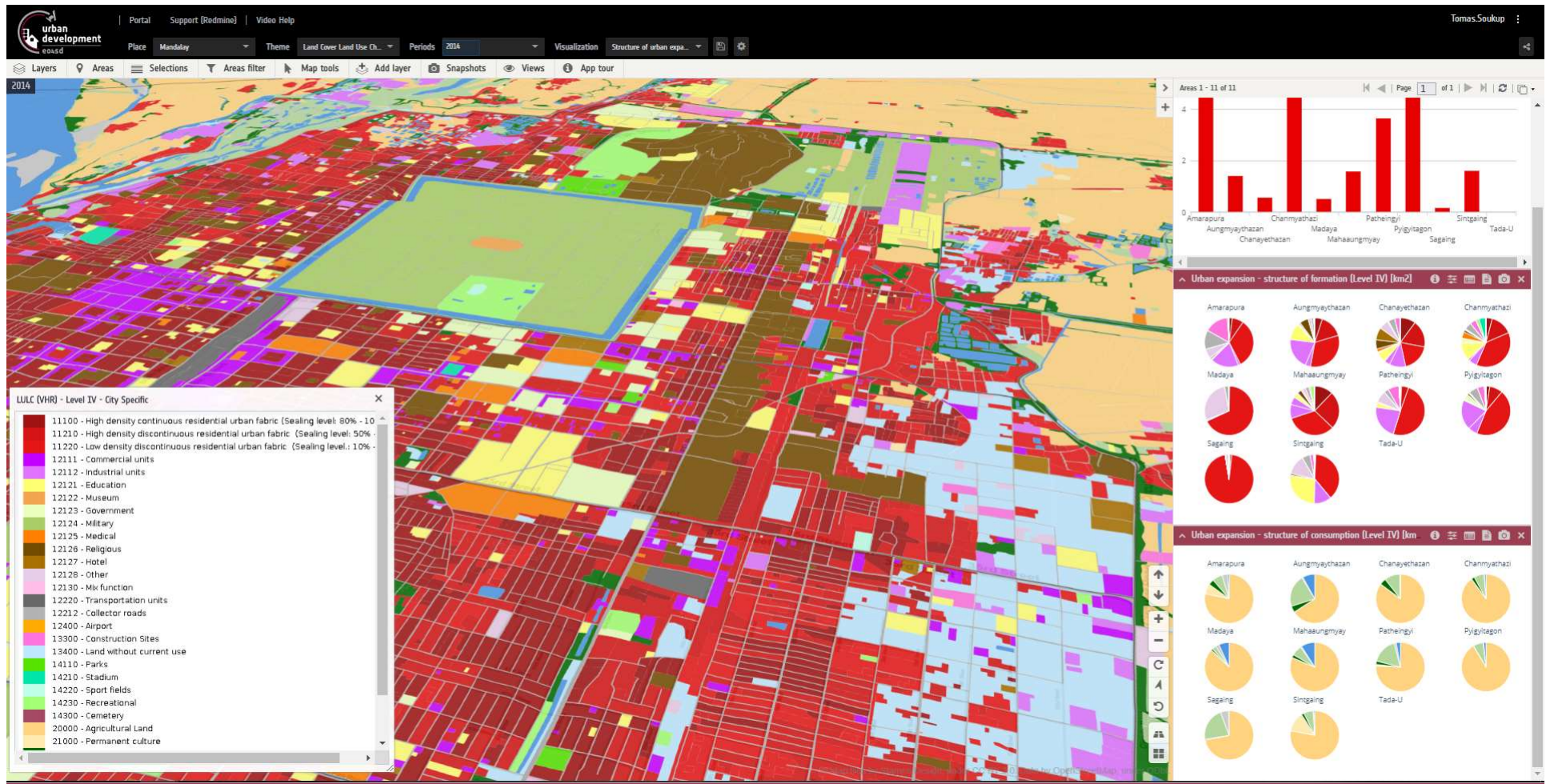


# (Peri-) Urban Land Cover / Land Use

## Regional and Detailed Products



Statistics – understanding intensity and ‘cons / forms’ flows





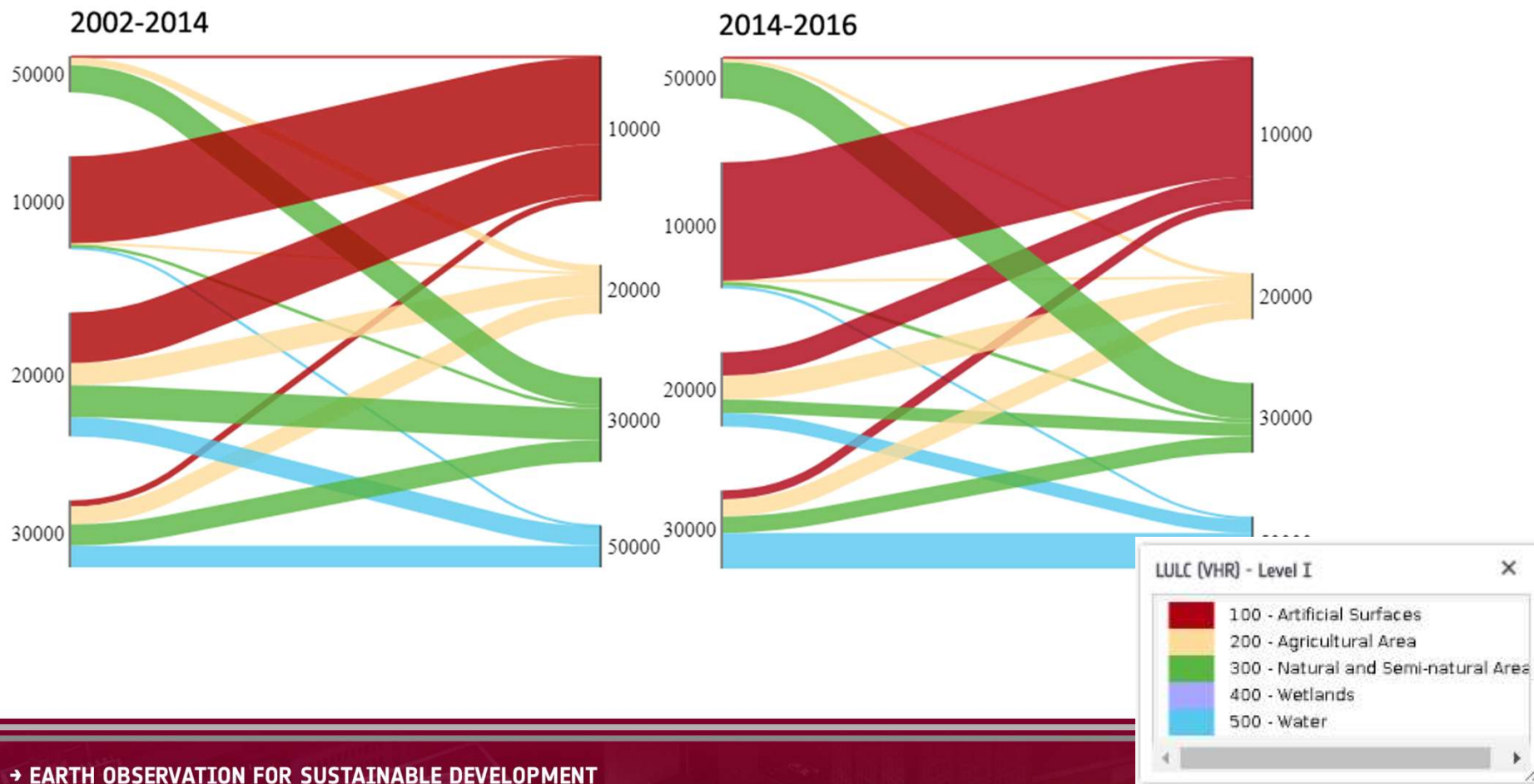
# (Peri-) Urban Land Cover / Land Use

## Regional and Detailed Products



Land Assets Statistics – comparison of trends - overall

### Mandalay (Myanmar) - Land Cover Flows Analysis - Overall







# (Peri-) Urban Land Cover / Land Use

## Regional and Detailed Products

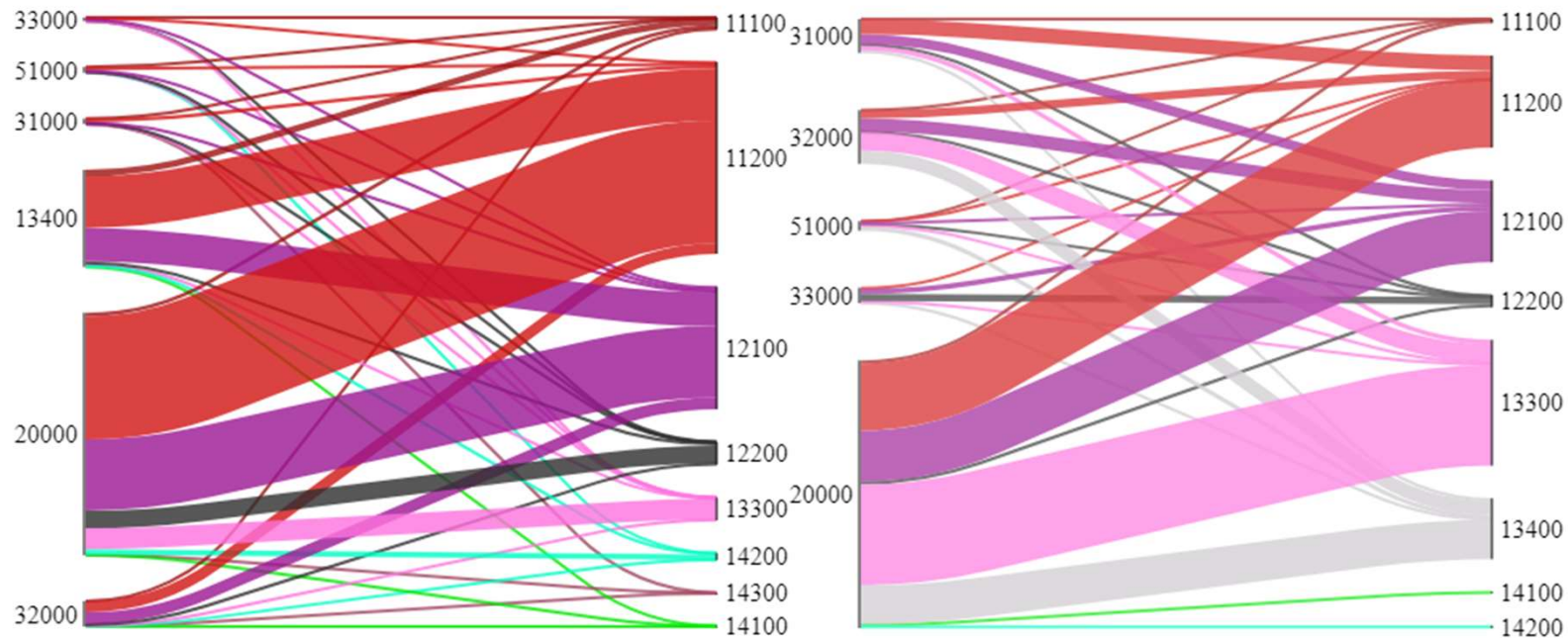


### Land Assets Statistics – Trends in Urban Expansion

#### Mandalay (Myanmar) - Land Cover Flows Analysis - Urban Expansion

2002-2014

2014-2016



LULC (VHR) - Level IV - City Specific

11100 - High density continuous residential urban fabric (Sealing level: 80% - 10	12220 - Transportation units	20000 - Agricultural Land
11210 - High density discontinuous residential urban fabric (Sealing level: 50%	12212 - Collector roads	21000 - Permanent culture
11220 - Low density discontinuous residential urban fabric (Sealing level: 10%	12400 - Airport	31000 - Forests
12111 - Commercial units	13300 - Construction Sites	32000 - Other Natural and Semi-natural Areas including Wetlands
12112 - Industrial units	13400 - Land without current use	33000 - Bare land
12121 - Education	14110 - Parks	51000 - Inland water
12122 - Museum	14210 - Stadium	
12123 - Government	14220 - Sport fields	
12124 - Military	14230 - Recreational	
12125 - Medical	14300 - Cemetery	
12126 - Religious		
12127 - Hotel		
12128 - Other		
12130 - Mix function		



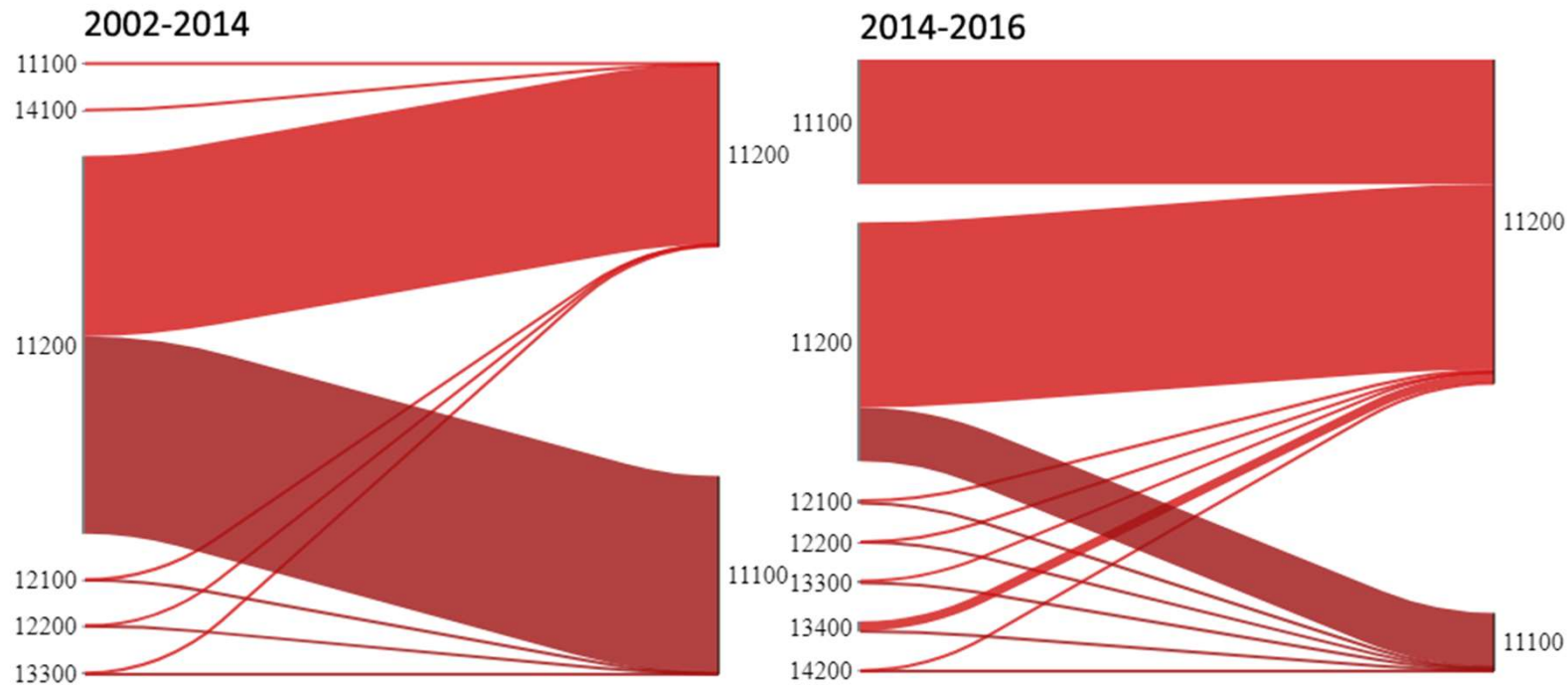
# (Peri-) Urban Land Cover / Land Use

## Regional and Detailed Products



### Land Assets Statistics – Trends in Urban Densification

#### Mandalay (Myanmar) - Land Cover Flows Analysis - Urban Densification



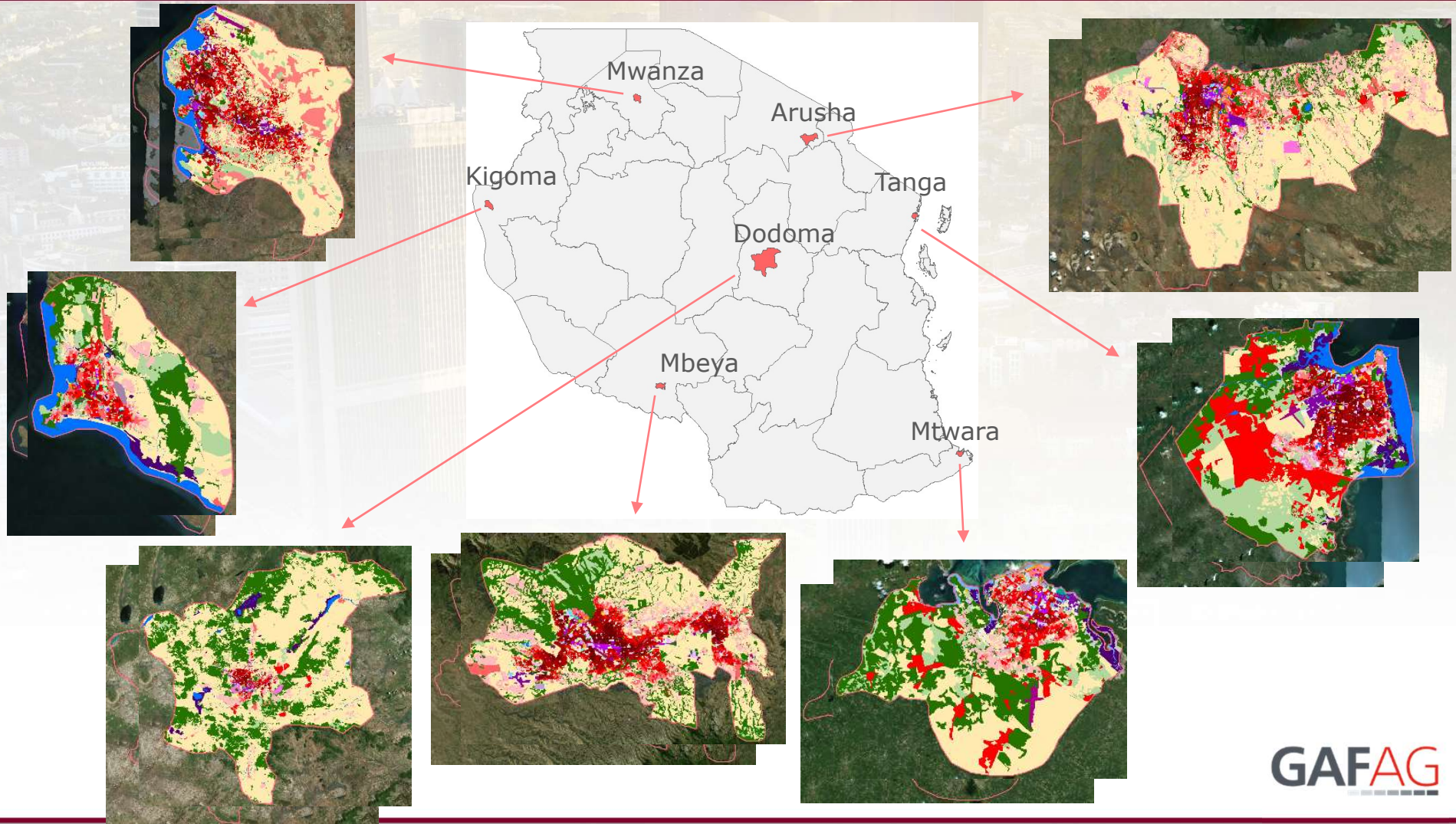
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12126 - Religious		
12127 - Hotel		
12128 - Other		
12130 - Mix function		



# Urban Planning

## Land Use / Land Cover Maps of Tanzanian Cities





# Comparative Analysis with existing Master Plan

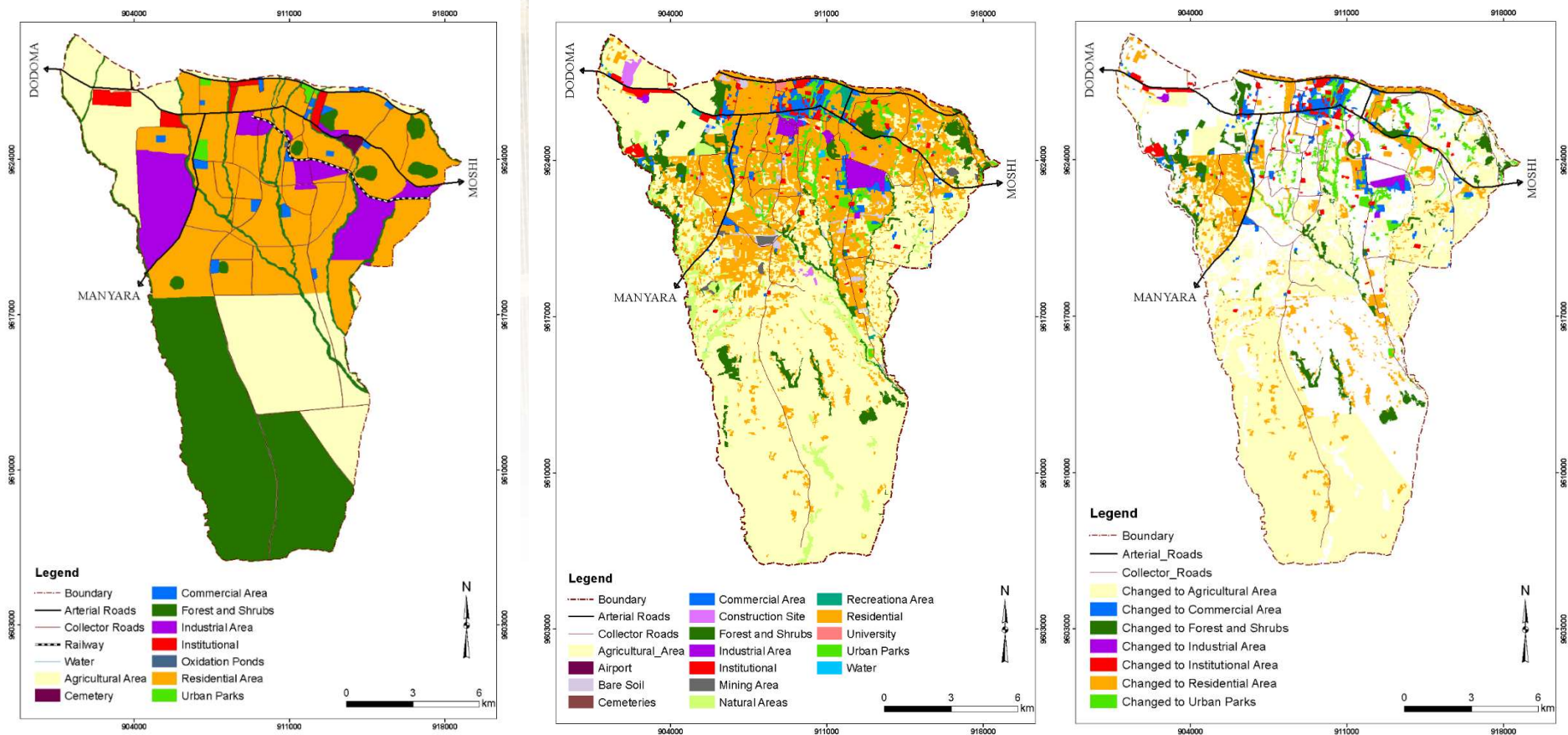


## Example Use Case – Arusha, Tanzania

1985 Master Plan

2015 Actual Land Use

Diversion from proposed land use



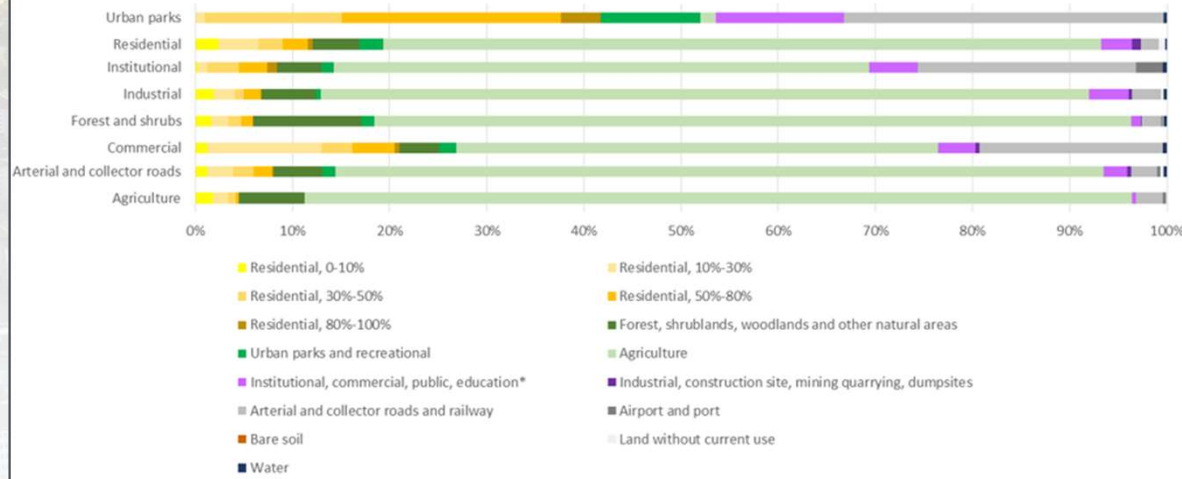
Source: Huang, C.Y. et al (2018): Translating Plans to Development, World Bank Group.



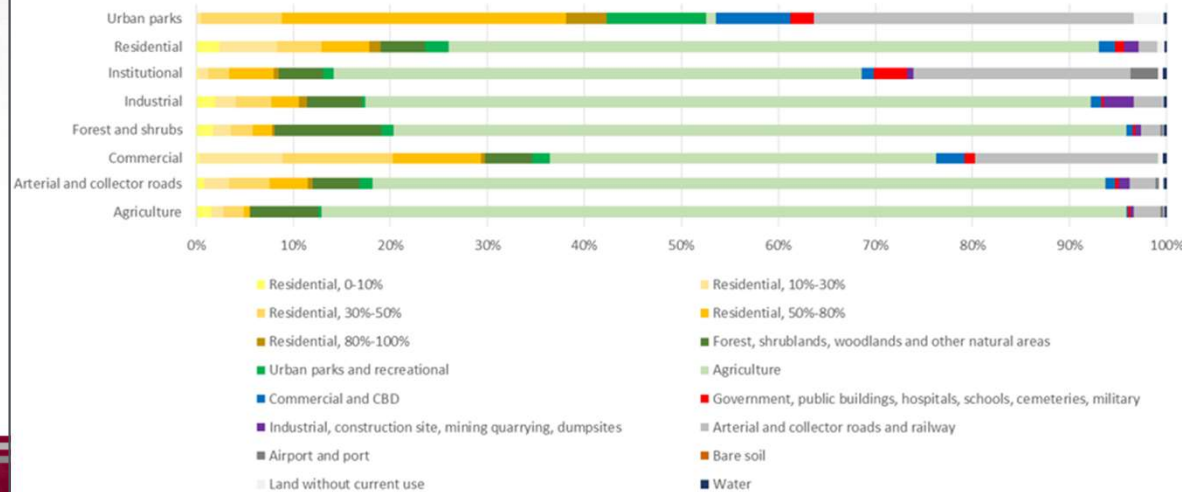
# Comparative Analysis with existing Master Plan



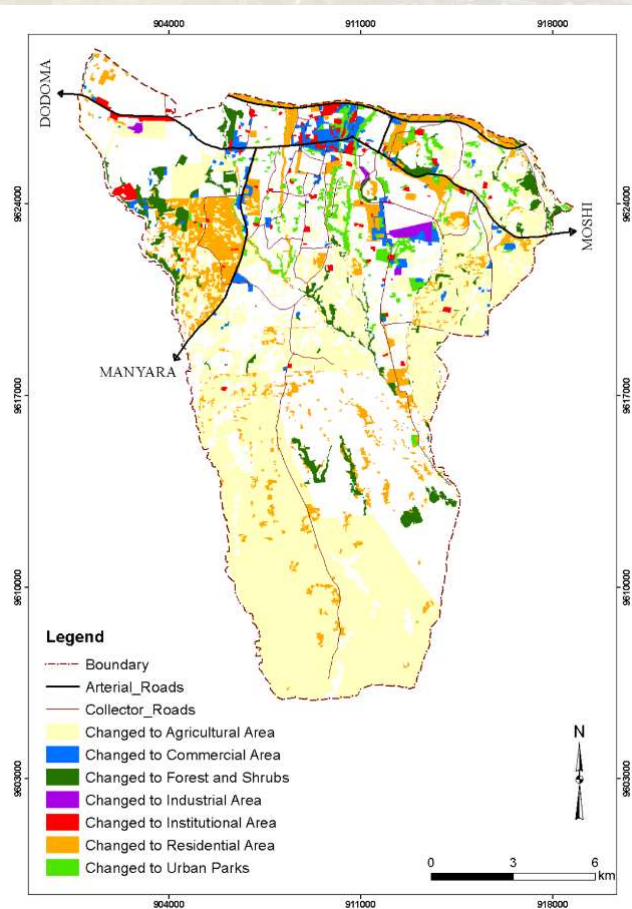
Comparison of existing land use (2005) to master plan (1985) in Arusha



Comparison of existing land use (2015) to master plan (1985) in Arusha



## Diversion from proposed land uses

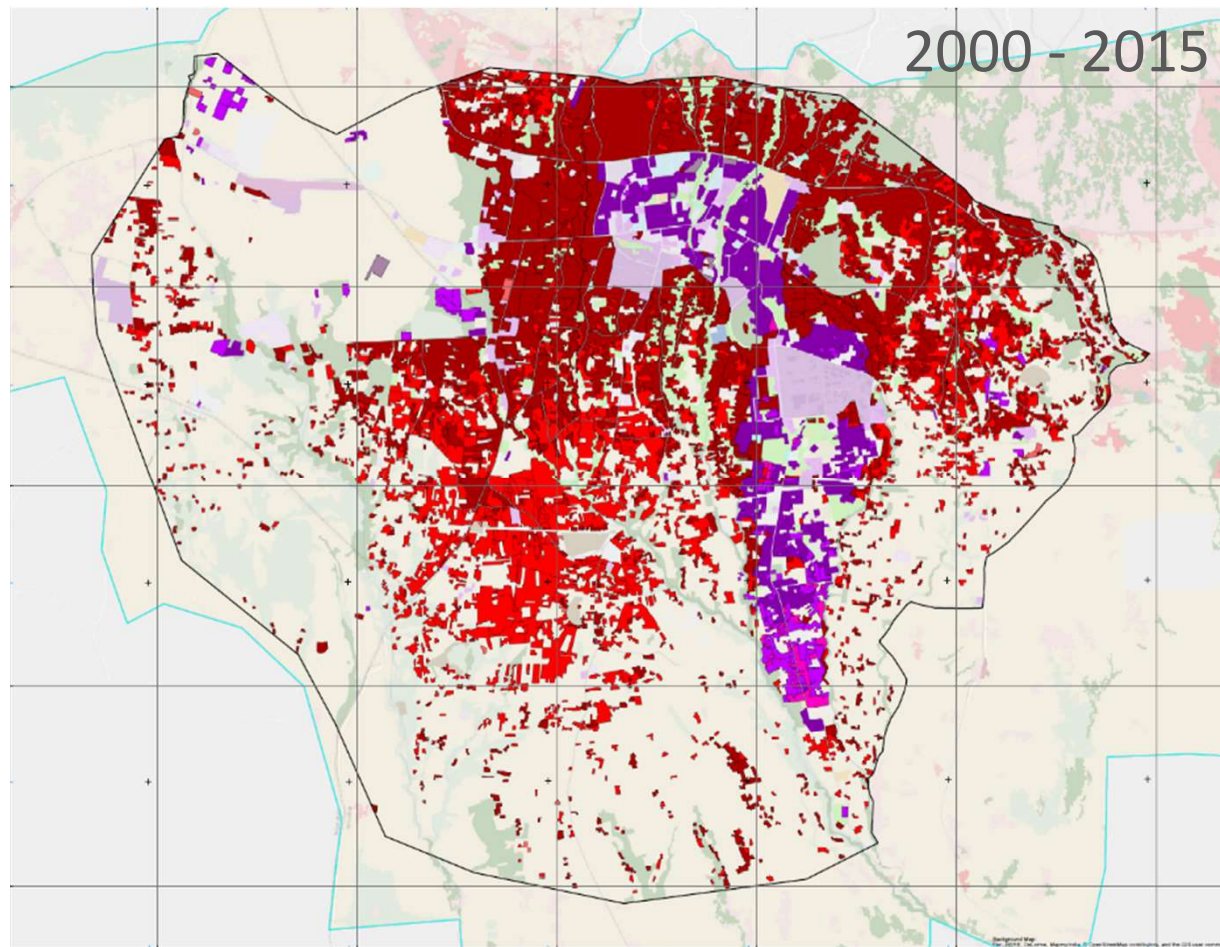


Source: Huang, C.Y. et al (2018): *Translating Plans to Development*. World Bank Group.

# Planned vs Unplanned Settlements



## Arusha City



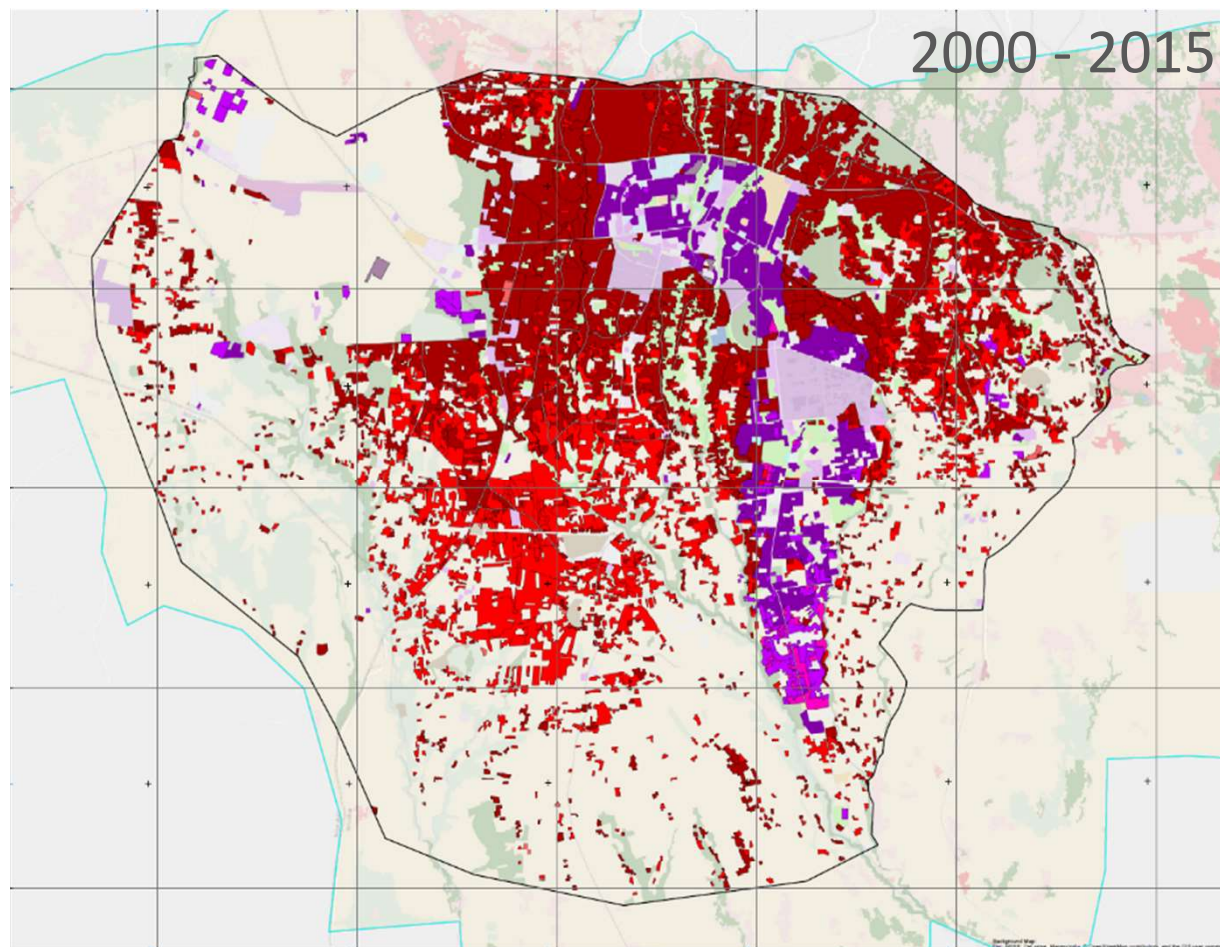
- Unplanned to planned settlements
- Decrease of unplanned settlements
- Expansion of unplanned settlements
- Expansion of planned settlements
- No change in unplanned settlements
- No change in planned settlements



# Planned vs Unplanned Settlements



## Arusha City

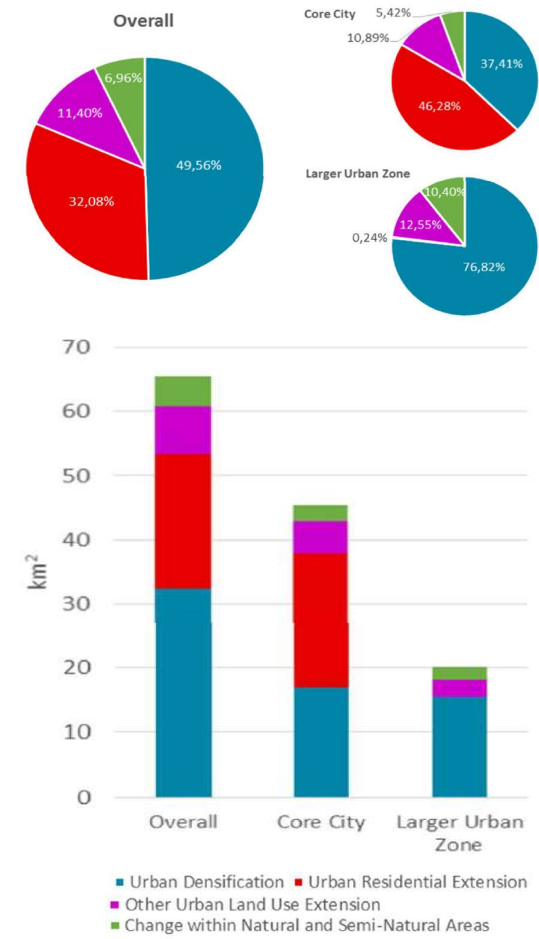
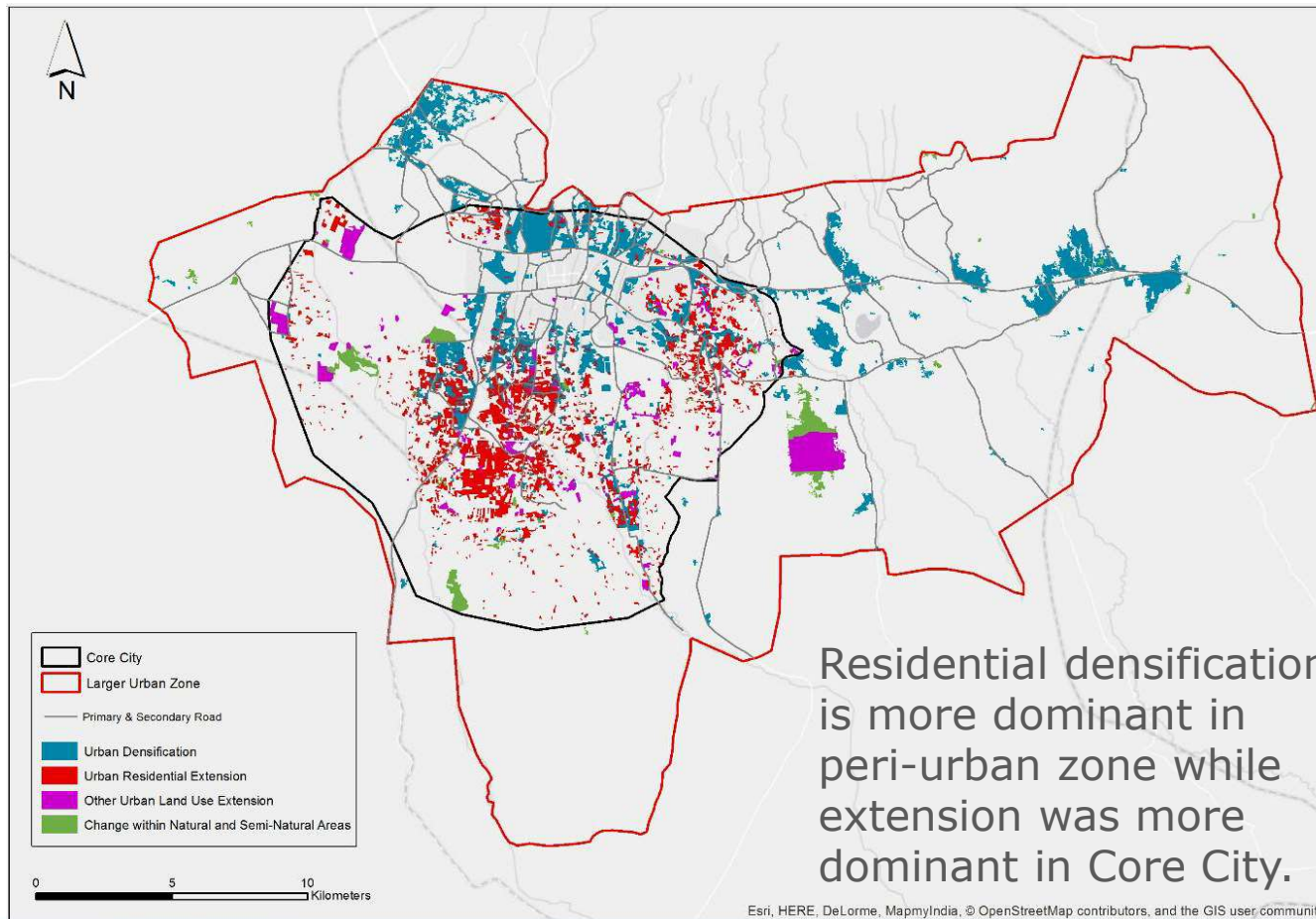


- Unplanned to planned settlements
- Decrease of unplanned settlements
- Expansion of unplanned settlements
- Expansion of planned settlements
- No change in unplanned settlements
- No change in planned settlements

# Land Cover Distribution and Changes



## Arusha City







# (Peri-) Urban Land Cover / Land Use

## Regional and Detailed Products



Land assets structure | SCUDEO | x

urban-tep.eu/visat/scudeoStories19/landAssetsStructure

GLOBAL URBAN GROWTH GREEN AREAS LAND ASSETS STRUCTURE

## City Land Assets Structure and Evolution

Earth Observation data can provide insight into Land Use and Land Cover (LULC) assets structure and evaluate quantity and quality of LULC changes

Land is a non-renewable resource and its quantity and quality play a vital role in the development of a city. Land structure and spatial-temporal patterns to a large extent influence city livability and resilience as well as determine physical constraints, opportunities and potential for further development.

**Saint Louis** ▾

Distribution and the spatial composition of LULC classes for two reference years is presented in the maps below. Pick the city from the pull-down menu on the top to display the maps for respective city.

Land Cover Land Use Structure

2003 2018

Land assets structure | SCUDEO | x

urban-tep.eu/visat/scudeoStories19/landAssetsStructure

### Land Cover Land Use Structure 2018

The graph above provides an overview of LULC structure (class % of the total area) in observed cities for a given reference year. Note: Lima - Only partial data are available, not complete city coverage.

### Total Area Changed 2003 - 2018

The graph above provides an overview of the amount of LULC changes (in km sq.) in observed cities for a given period. Note: Lima - Only partial data are available, not complete city coverage.

### Land Cover and Land Use Changes

2003 ▾ Change flows: 2003 - 2018

As EO4SD-Urban contribution to the GPSC's 3rd Global Meeting Land Use Land Cover Assets Storyline for several Cities is available at <https://urban-tep.eu/visat/scudeoStories19/landAssetsStructure>

## Planning on building or building block level

- What is building density, distribution, size?
- Formal or informal settlements ?
- What is the population density ?
- What is the buildings utility (space efficiency, building occupancy) ?
- Are there trends of their change ? Positive or negative ?
- Where are the hotspot ?





# Building Footprints

## Very Detailed Local Product



- Building footprints - contour of buildings close to cadastral systems representation
- Detailed information on individual buildings or building blocks

Product is realized either by semi-automatic feature extraction or visual interpretation of commercial VHR imagery (sub-meter pixel resolution) with a help of auxiliary information (e.g. OSM).

- 3D Models
- Urban air pollution modelling
- Thermal comfort modelling
- Cadaster reality check
- Tax valuation modelling



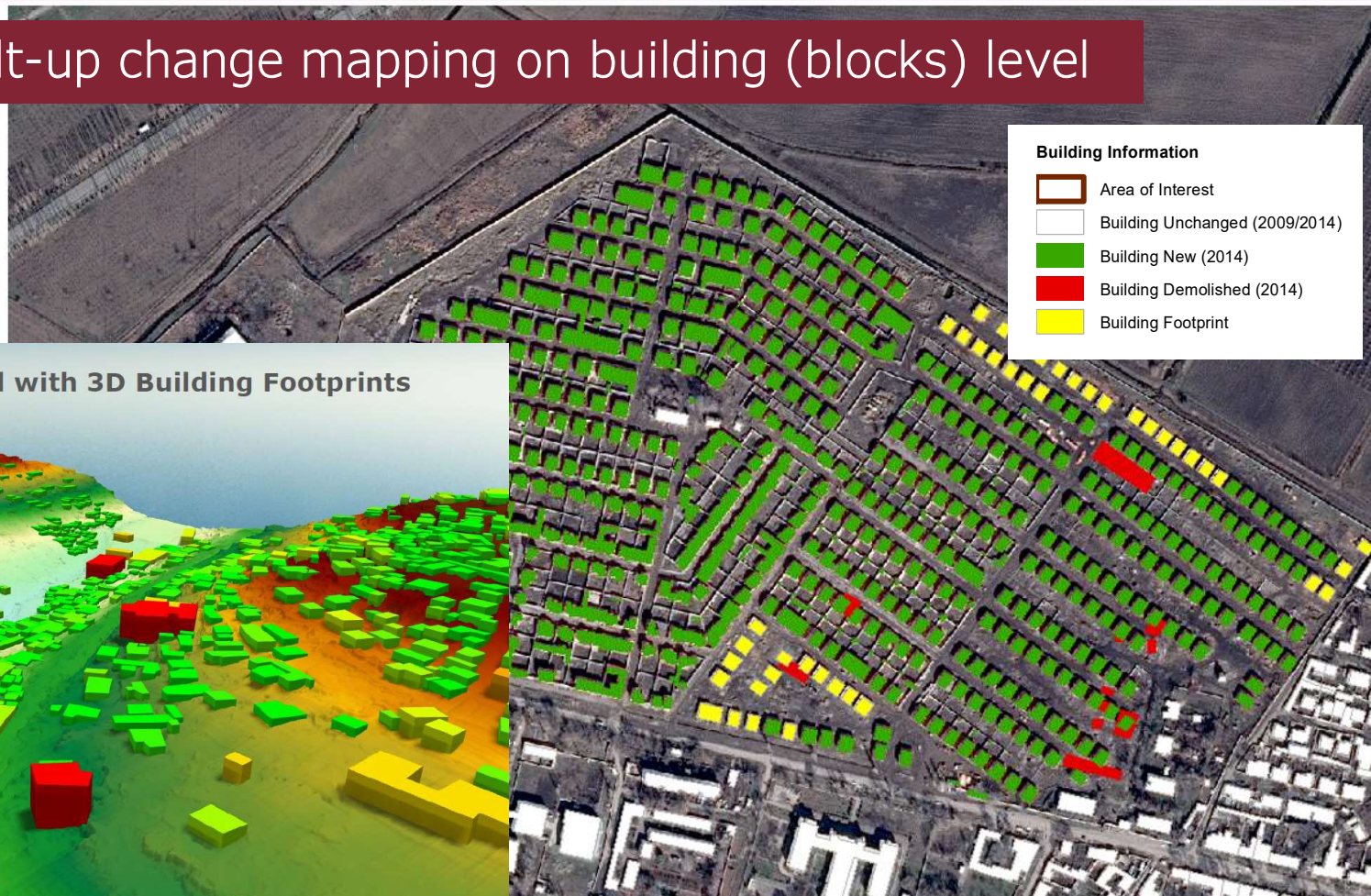


# Building Footprints

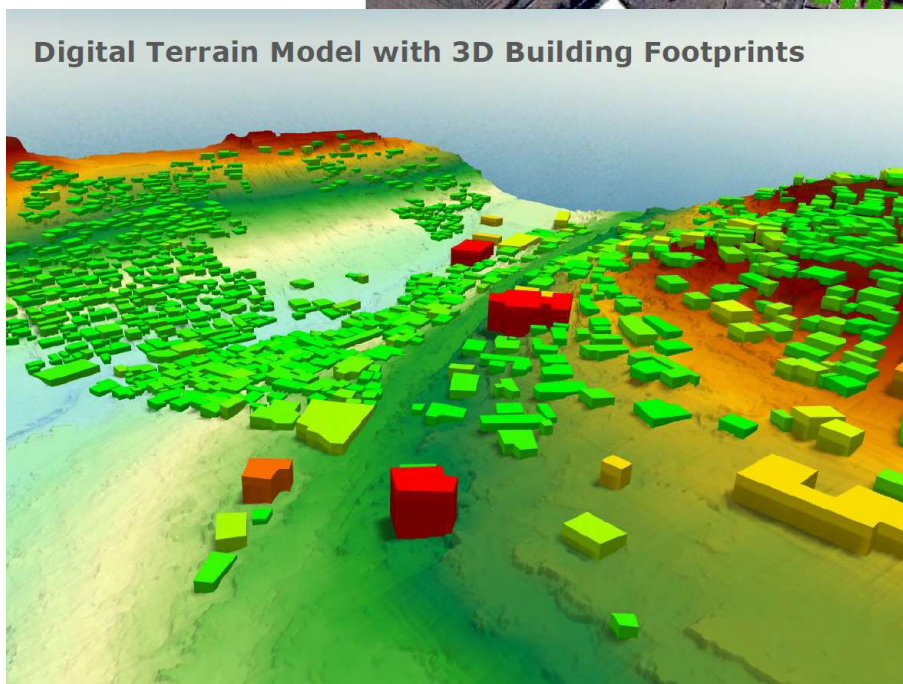
## Very Detailed Local Product



Detailed built-up change mapping on building (blocks) level



Digital Terrain Model with 3D Building Footprints





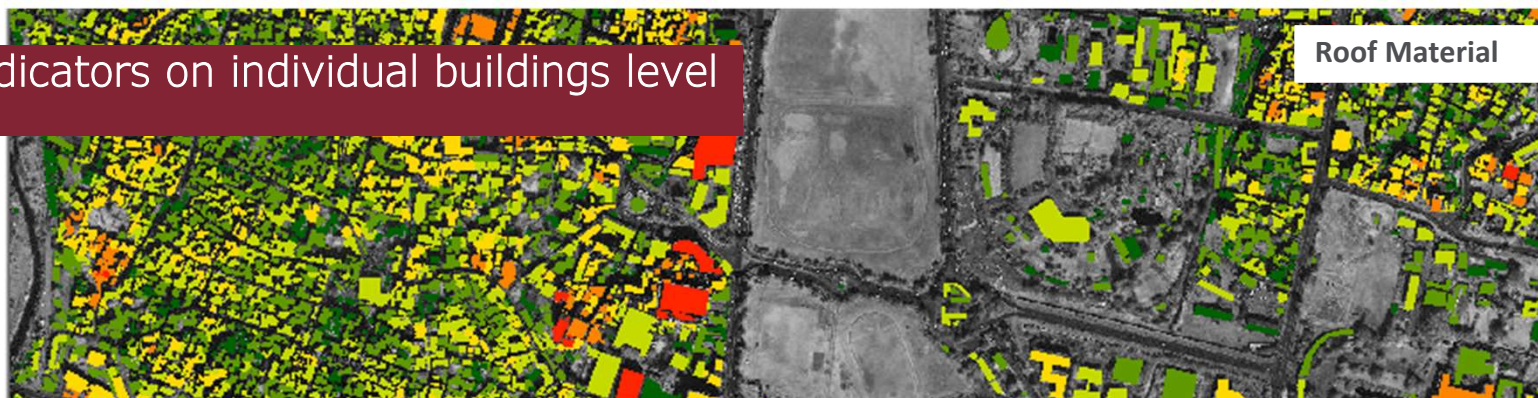


# Building Footprints

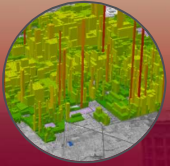
## Very Detailed Local Product



Structural indicators on individual buildings level







# Population Density

## Local Product



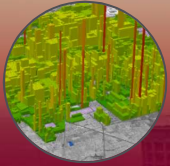
- Spatial distribution of population (population density proxy)

The product provides spatial disaggregation of population density produced using modelling from Census statistic and Building footprint, Land Cover / Land Use or Soil Sealing datasets. Provides more precise information about spatial distribution of population in city.

- Access to services
- Mobility studies
- Heat impact studies
- Risk analysis



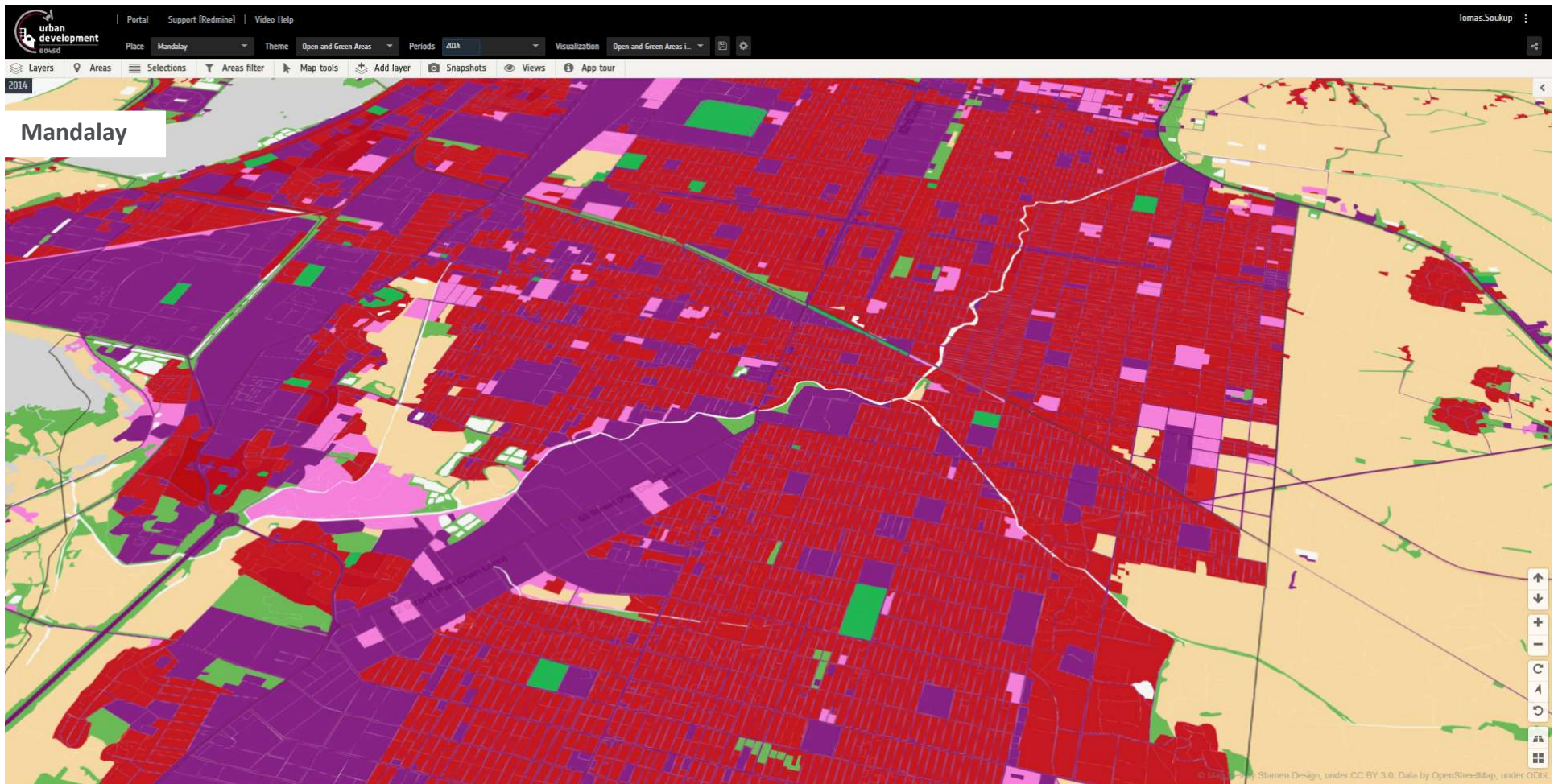




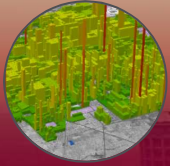
# Population Density Local Product



LULC, Census Data and VHR DSM for urban blocks



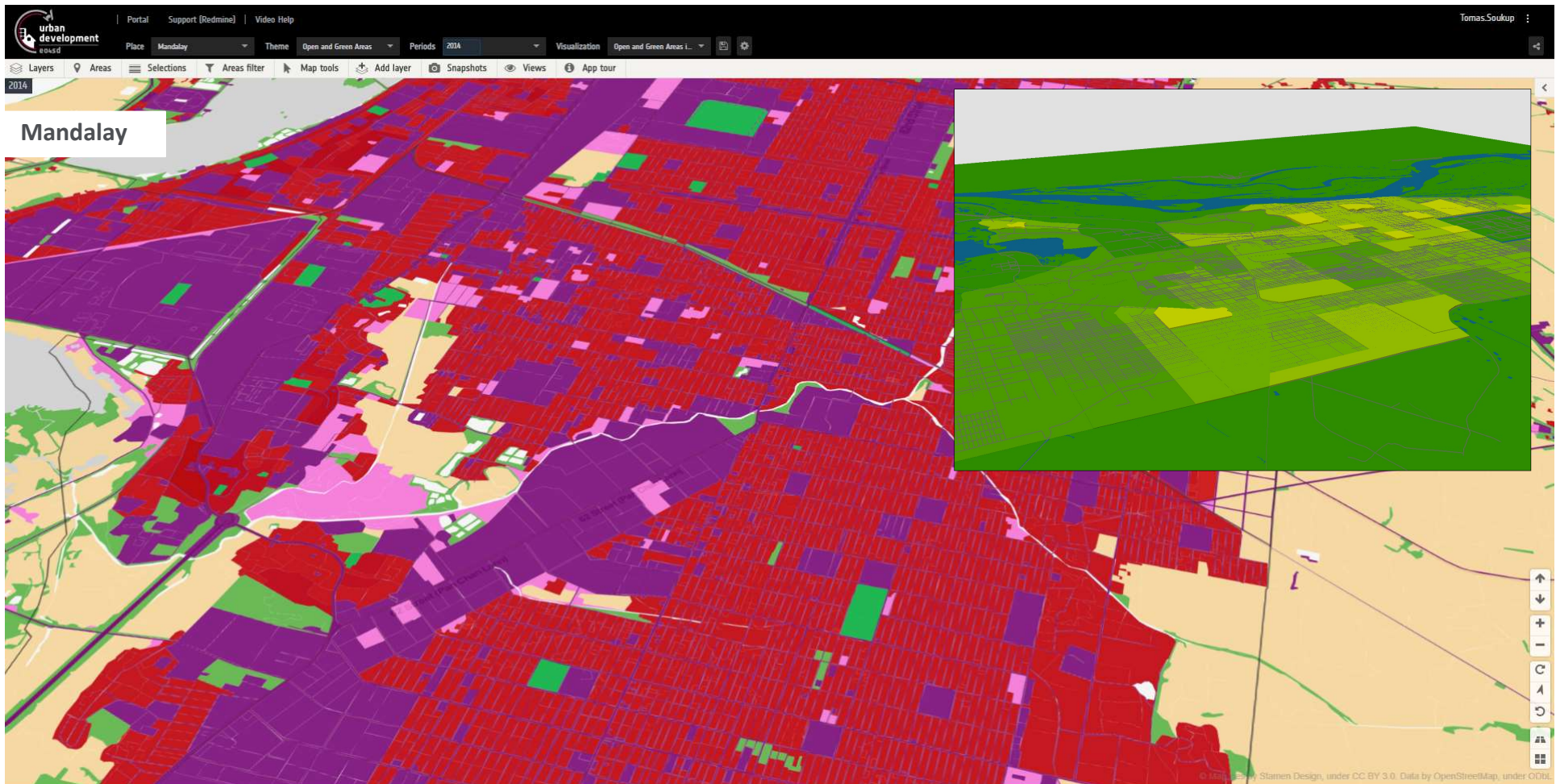




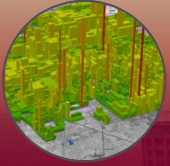
# Population Density Local Product



LULC, **Census Data** and VHR DSM for urban blocks







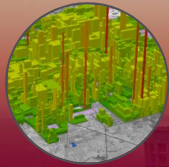
# Population Density Local Product



LULC, Census Data and **VHR DSM** for urban blocks

urban development  
Portal Support (Redmine) Video Help  
Place Mandalay Theme Open and Green Areas Periods 2014 Visualization Open and Green Areas L.  
Layers Areas Selections Areas filter Map tools Add layer Snapshots Views App tour  
2014  
Mandalay  
→ EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT  
Urban development  
European Space Agency



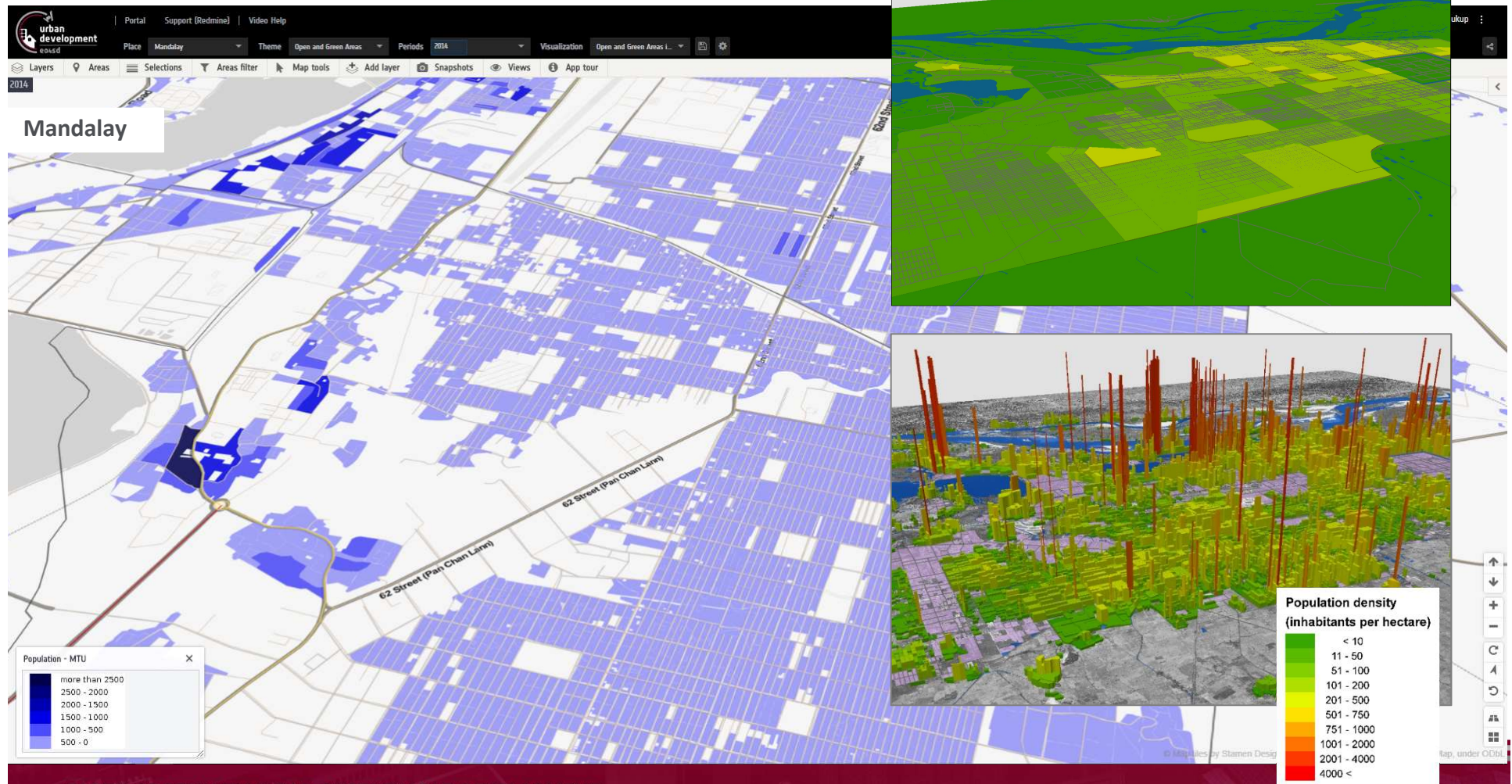


# Population Density

## Local Product



## Population census disaggregation

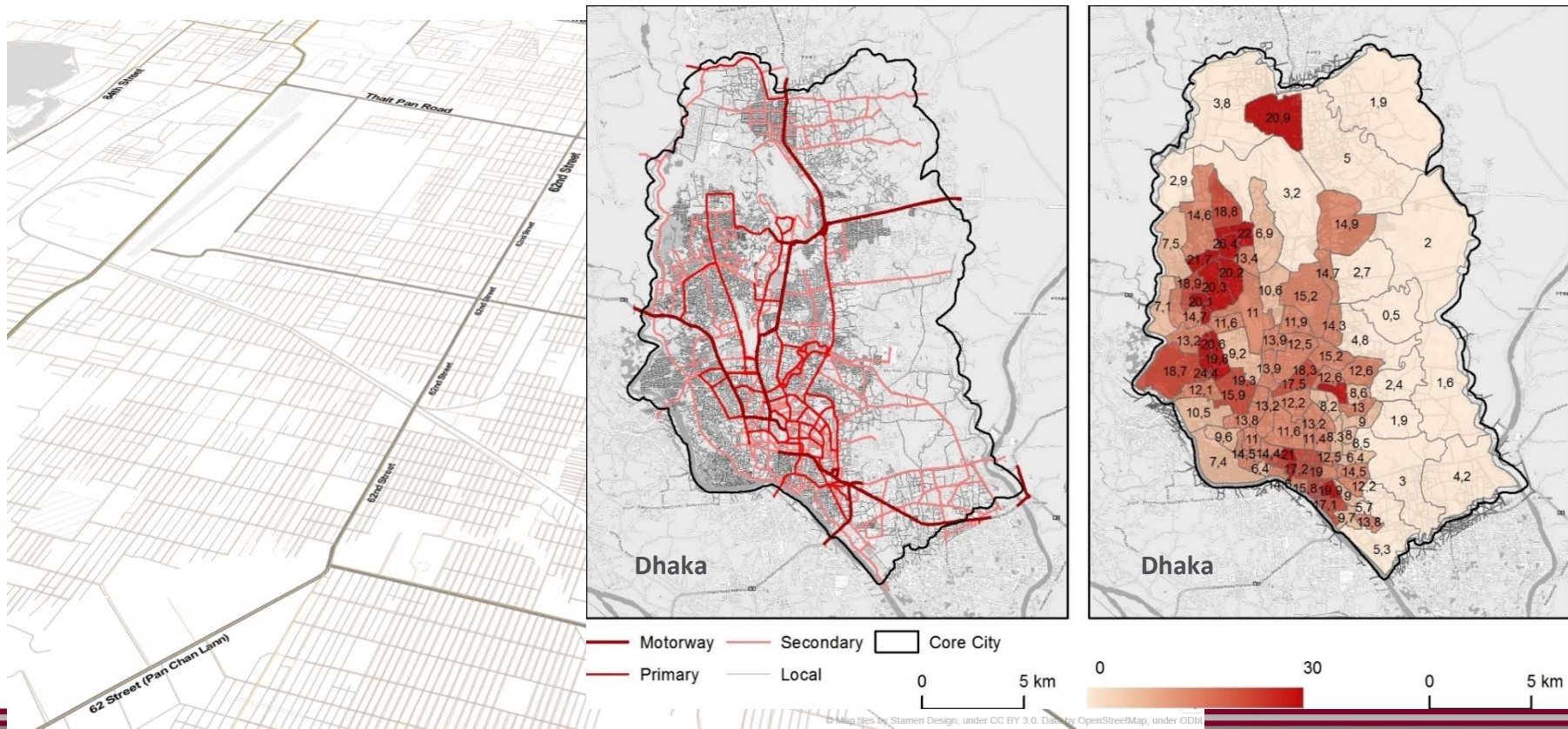




A street density (road surface / total area) gives a quick understanding about the typology of the City.

Transportation network map

Network density

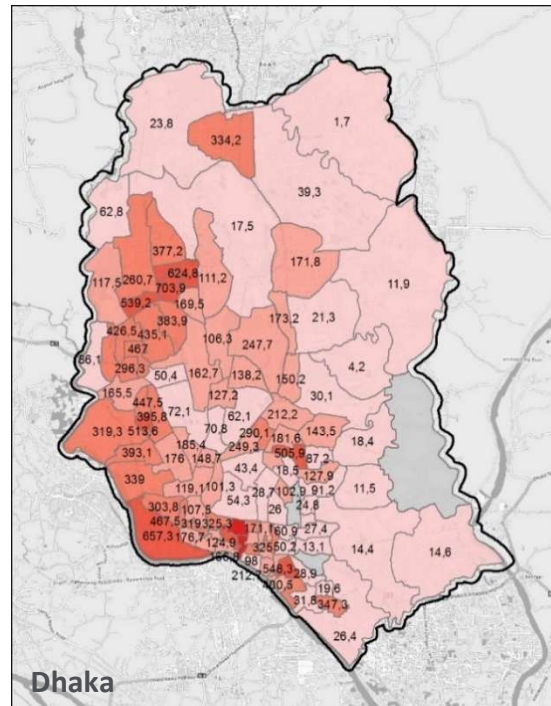


Street density and connectivity can be used as a proxy of **urbanity** (i.e. highly urbanized areas have denser street grids) and **walkability**.

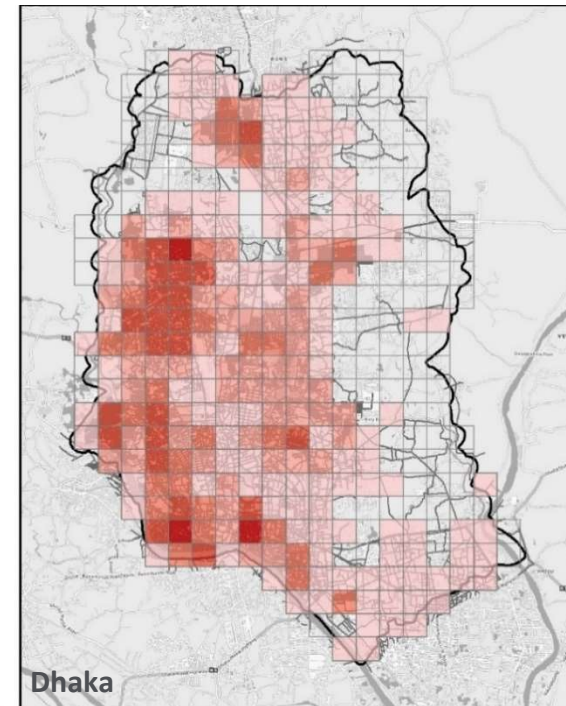
Streets and public spaces support the livelihoods of many residents, such as vendors, and facilitate social interaction within communities.

The density of intersections is often used as a measure of mobility and safety on streets.

No. intersections/urban fabric/ward



Density of intersections/sq.km



□ Core City  
□ No connectivity nodes in ward

0 1000 2000

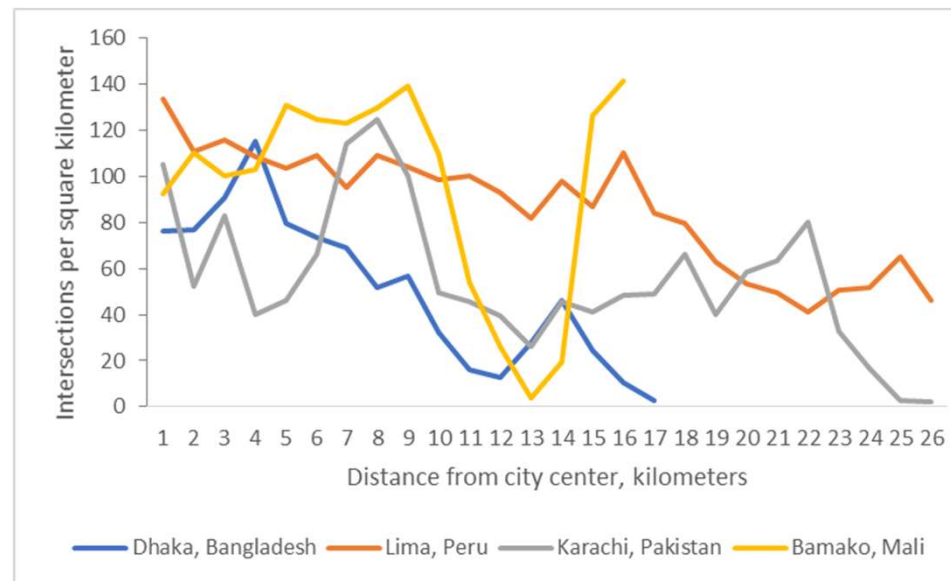
0 5 km 0 1200 0 5 km



Street density and connectivity can be used as a proxy of **urbanity** (i.e. highly urbanized areas have denser street grids) and **walkability**.

Based on the benchmark of 100 intersections per km<sup>2</sup> as an ideal threshold for walkability (UN-Habitat 2013), cities generally fall short of this benchmark, but with great variation across neighbourhoods within each city.

**Intersection density / urban fabric / distance from the centre (CBD)**

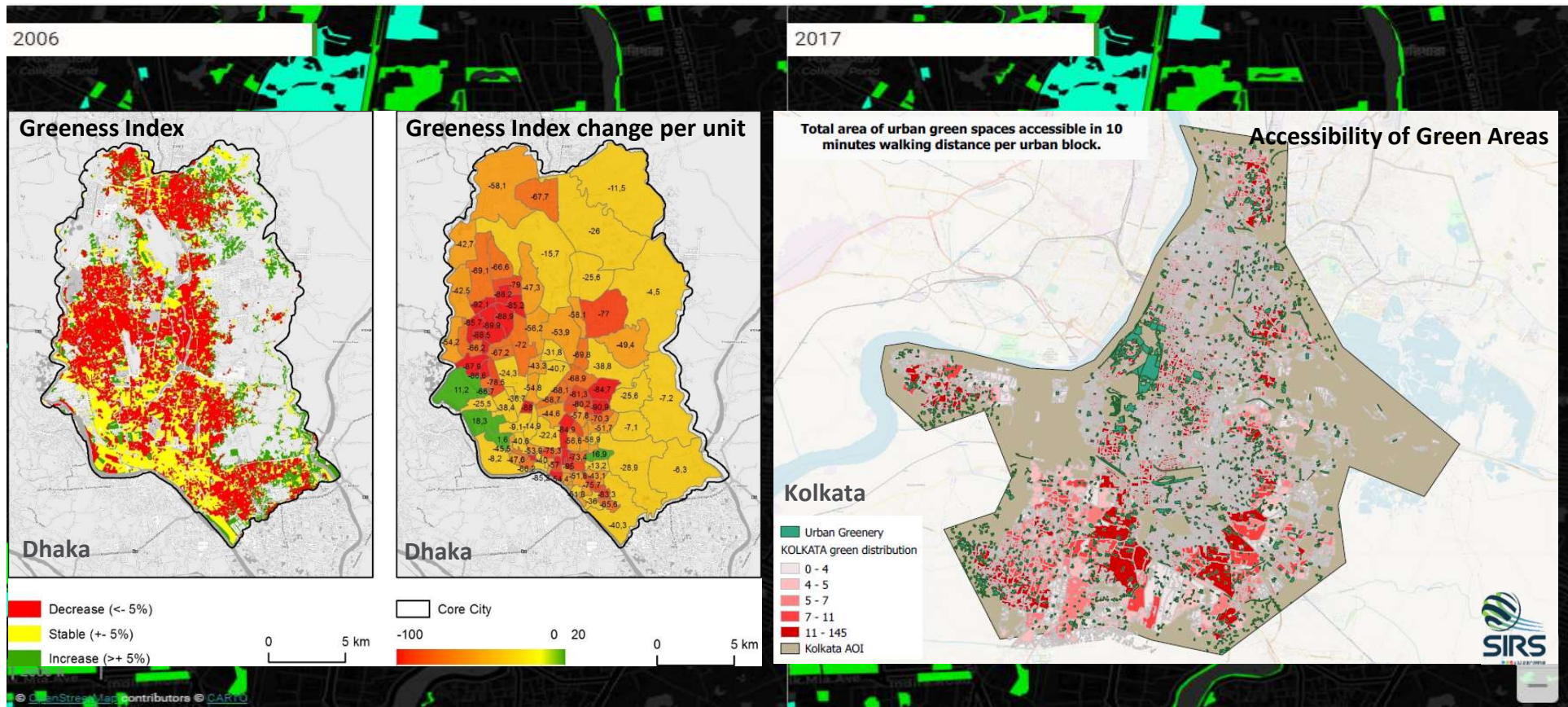


Source: World Bank, based on 2019 EO4SD-Urban data

# Green Areas



Green Areas help in reduction of the energy costs of cooling buildings effectively. Due to their amenity and aesthetic, green areas increase property value. Green areas in a city are also the social and psychological benefits.





# Green Areas



Green areas | SCUDEO Stories

urban-tep.eu/visat/scudeoStories19/greenAreas

GLOBAL URBAN GROWTH GREEN AREAS LAND ASSETS STRUCTURE

## Mapping and monitoring of urban green areas

How green, open and public spaces are defined – opportunities and limitations.

EO4SD-Urban provides a range of tailored products derived by advanced analysis of recent very high resolution satellite imagery to describe distribution of urban green areas in the city, their structure and typology and evolution over the time. This presentation brings simple but powerful examples of mapping and statistical outputs derived directly from EO4SD-Urban's Urban Green baseline products, which provide means for high level comparative analysis between different cities.

Abidjan

Distribution of artificial green areas (consisting of two classes) in the current year is presented in the map format. Pick the city from pull-down menu in the top-left corner to display the map for respective city. Status in former time horizon (as mapped using archived imagery) and changes between the two horizons can be presented in the same manner to show spatially explicit patterns of areas subject to transition: either uptake (formation) of former green areas by other classes or their consumption e.g. by urban sprawl or infilling.

Green Areas Distribution

2005

2018

Land assets structure | SCUDEO

urban-tep.eu/visat/scudeoStories19/landAssetsStructure

### Green Areas Share (%)

Graph shows comparison of relative metric: share of artificial urban green areas on total area of the city, and on total area of artificial urban areas (urban fabric).

### Green Areas vs. City Total Area

Scatter plot facilitates identification of clusters depending on relationship between total size of the cities and total area of their green areas. The bubble size represents population as of 2018 / 2019 (source: United Nations, 2018; World Population review, 2019).

### Urban Green Area (km<sup>2</sup>)

Abidjan 2005/2018

Graph shows overall area of urban green in two time horizons.

### Green Area Flows

Abidjan 2005/2018

- Discontinuous dense residential urban fabric (50% - 80% sealed)
- Commercial and industrial uses
- Collector roads
- Construction sites
- Land without current use (Vacant Land not obviously being prepared for construction)
- Urban Greenery

As EO4SD-Urban contribution to the GPSC's 3rd Global Meeting Green Areas Storyline for selected cities is available at <https://urban-tep.eu/visat/scudeoStories19/greenAreas>

# Public Space – Green and Open Areas



## Public Space - How far we can go remotely ?



Service: Identification, quantification and characterization of potential public\_urban spaces (using EO)

Coherent with SDG 11.7 implementation (UN-HABITAT)

Urban Spaces:

Open and Green Spaces

Streets

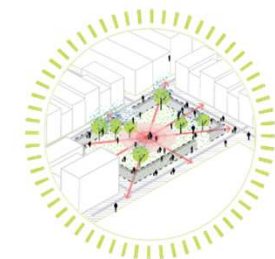
Building



ACTIVE BUILDINGS



COMFORTABLE STREETS



NATURAL OPEN SPACES

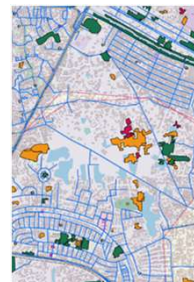


## Methodology via GOA Characteristics

- For each candidate GOA object several indicators are derived by OBIA and GIS
- 6 base GOA indicators are used as criteria for classification of potential PS

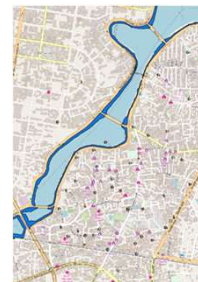
Indicator group	Indicator
Distance and accessibility	Distance to roads, amenities
	Distance to water
Patterns	Shape linearity, size, compactness
	Vegetation typology (high, low, bare)
	Park probability indicator
	LULC patterns and proportions
Contextual	Built-up proportions and adjacency
	LULC adjacency

**C1.**  
Distance to nearest Road?



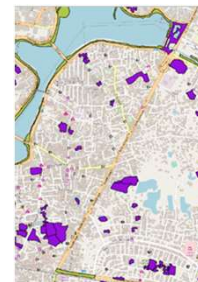
Very accessible (<10m)  
Accessible (<100m)  
Inaccessible (>100m)

**C2.**  
Adjacent to Water



Waterfront

**C3.**  
Compactness:  
Linear or not



Linear  
General

**C4.**  
Patterns



High vegetation  
High built up and open  
Horticultural management

**C5.** Location  
(Urban Mask)



Urban Vs suburban

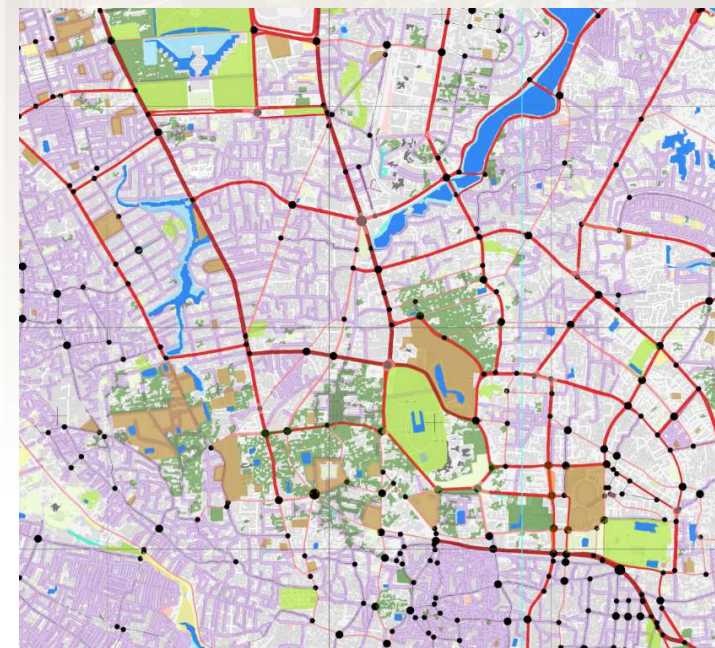
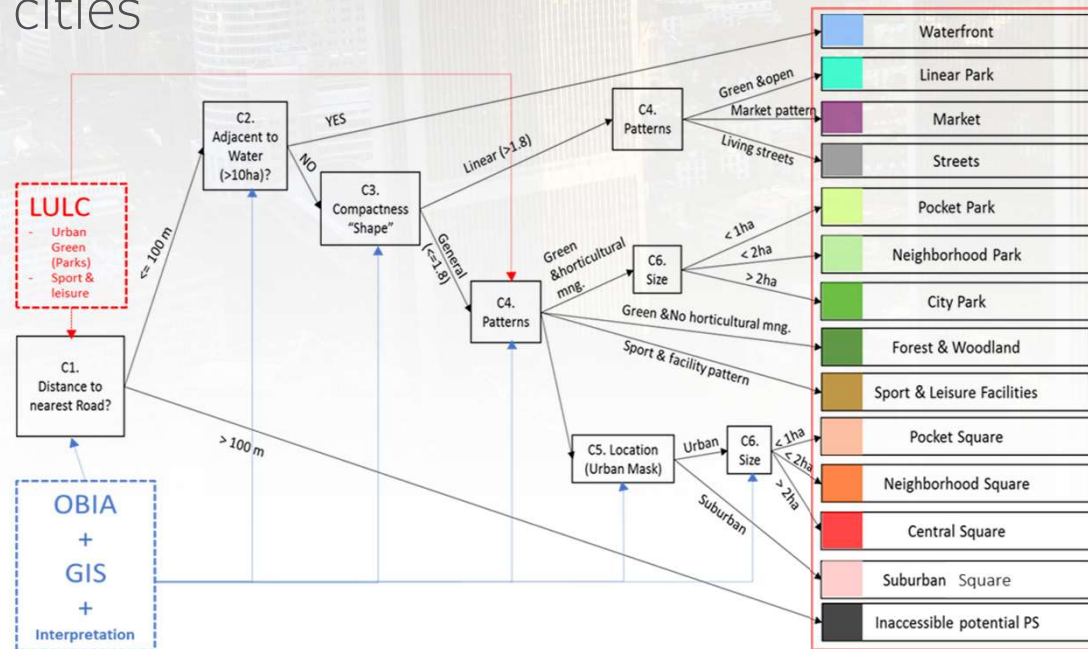
**C6.** Size



Pocket (1ha)  
Neighborhood (<2ha)  
City

## Rule-based GOA typology

In order to better understand multi-faceted characteristics of public spaces, a rule-based typology has been developed and applied in case cities





# Public Space – Green and Open Areas



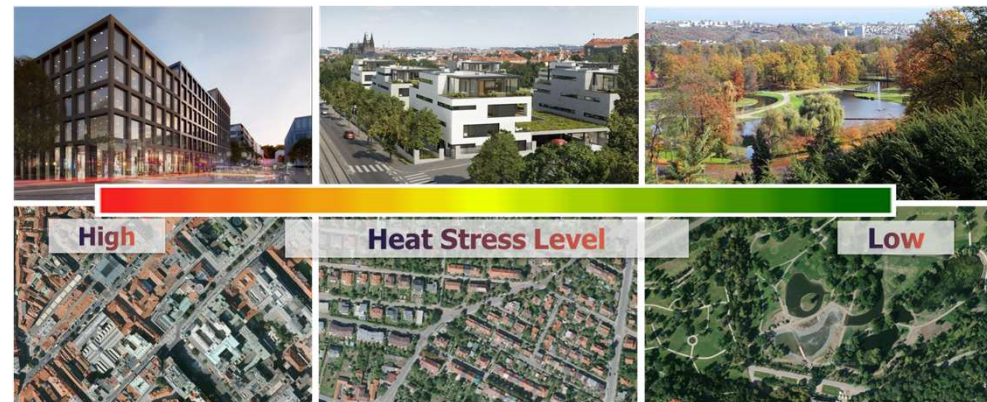
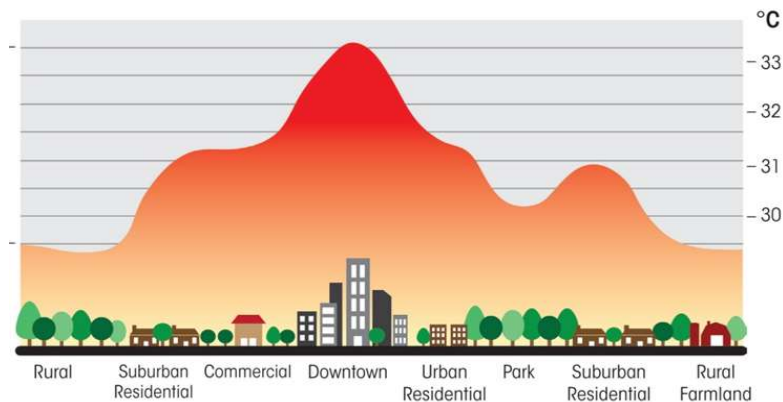
## EO Part of the Full Planning Cycle



City structure (LU/LC) links to a climate conditions in the city (distribution of heat-stress)

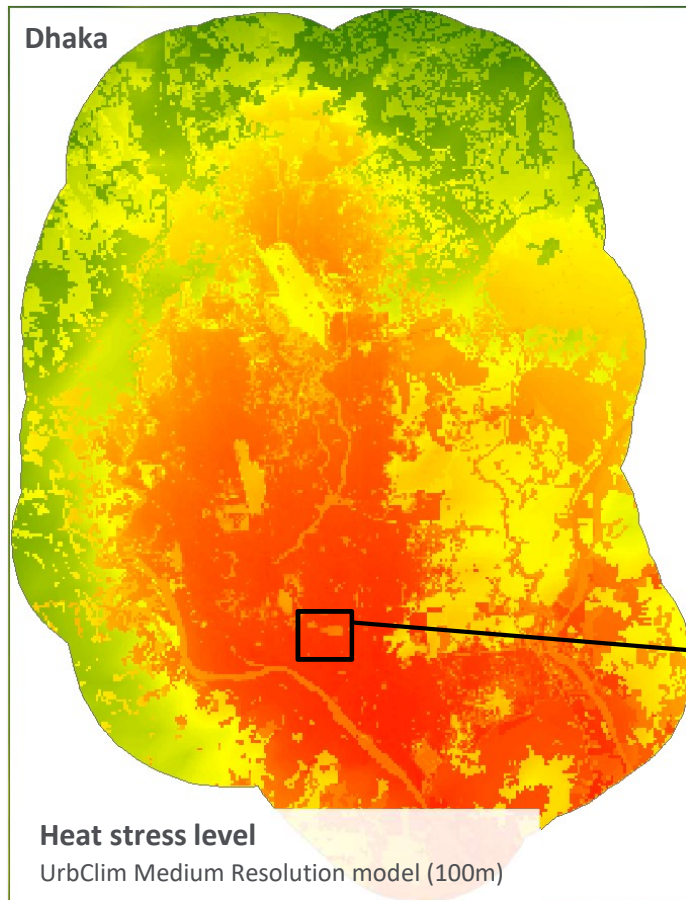
- Lack of vegetation: low evapotranspiration/no shadows
- Heat absorbed by buildings and artificial surfaces
- Solar radiance reflected from building-walls etc.
- Decreased air-flux in „street canyons“
- Anthropogenic heat from air-conditioning and traffic exhalations

## Urban Heat Island effect





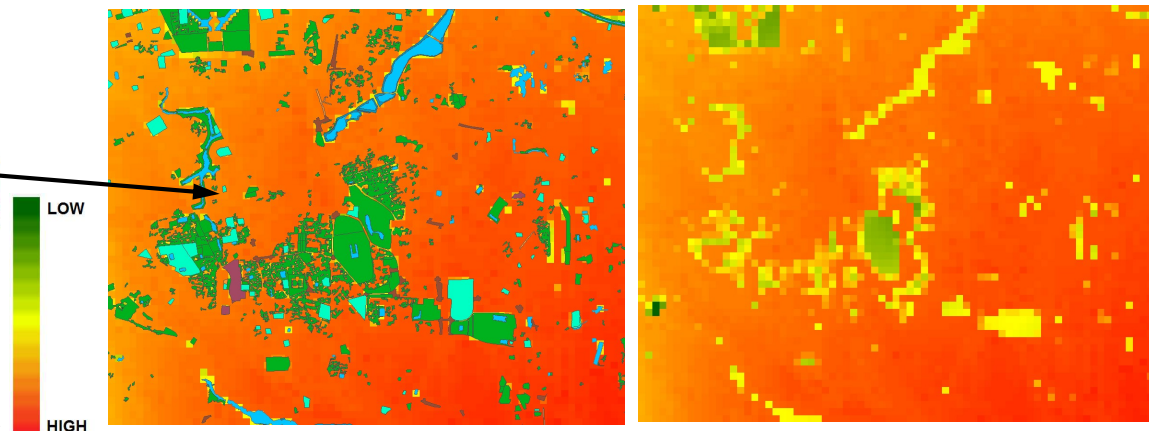
City-level planning, hot-spots, long-term development strategies



## Urban Heat Island (UHI) intensity

Average difference in 2m air temperature comparing to coldest location in the model domain at the moment of maximum urban heat island intensity

## Cooling effect of Green Areas



# Heat Intensity / Heat Stress

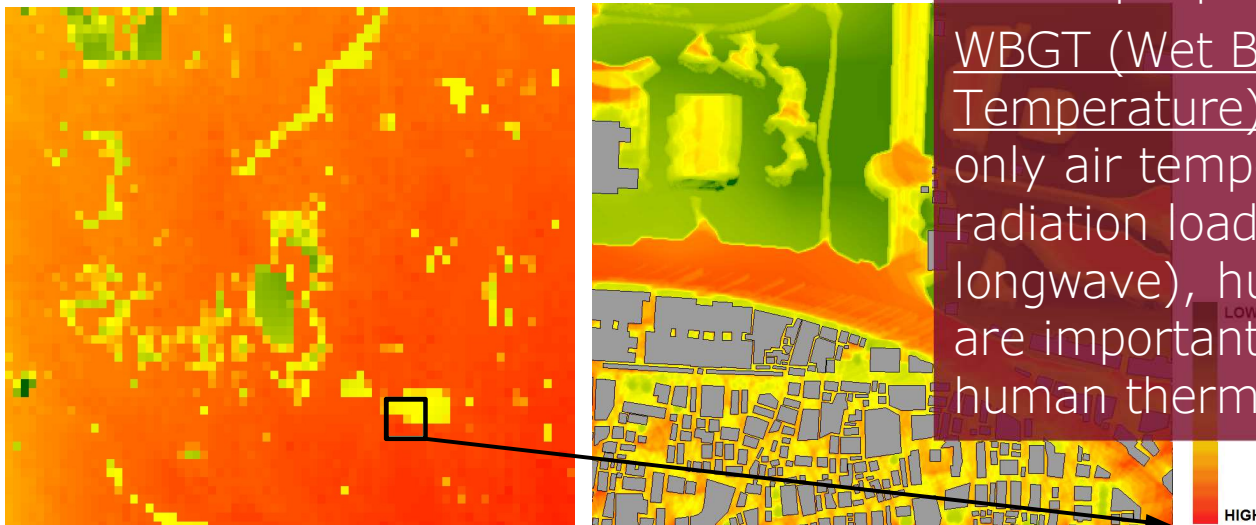


Hot-spots identified subject of detailed modeling of the heat stress in specific areas of interest inside the city in very high spatial detail (1m)

## Heat Stress Index (WBGT Index)

is a wide spread used indicator (ISO 7243:2017) for assessment the impact of urban climate environment on the people in the city.

WBGT (Wet Bulb Globe Temperature) takes into account not only air temperature, but also the radiation load (both shortwave and longwave), humidity and wind speed are important factors to quantify human thermal comfort.





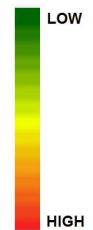
# Heat Intensity / Heat Stress



Improvement planning of local Heat Stress situation

Modelling local user-defined design scenarios

Different distribution of new buildings, trees (crown size, height) and paved or unpaved surfaces



Heat stress level





# Informal Settlements / Slums



## Potential slums detection and delineation



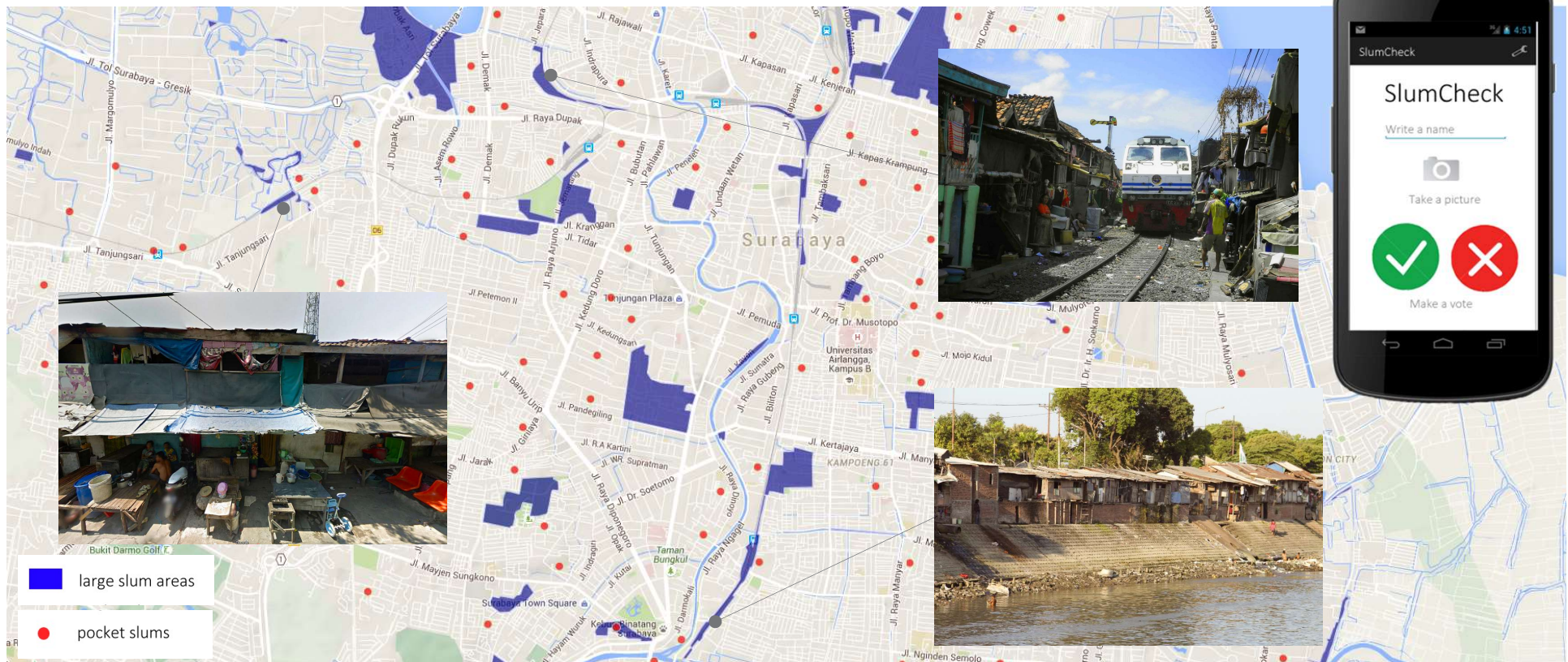
Mapping © ESA 2012, Image © WorldView, DigitalGlobe 2012



# Informal Settlements / Slums



On-site verification (e.g. crowd source supported)

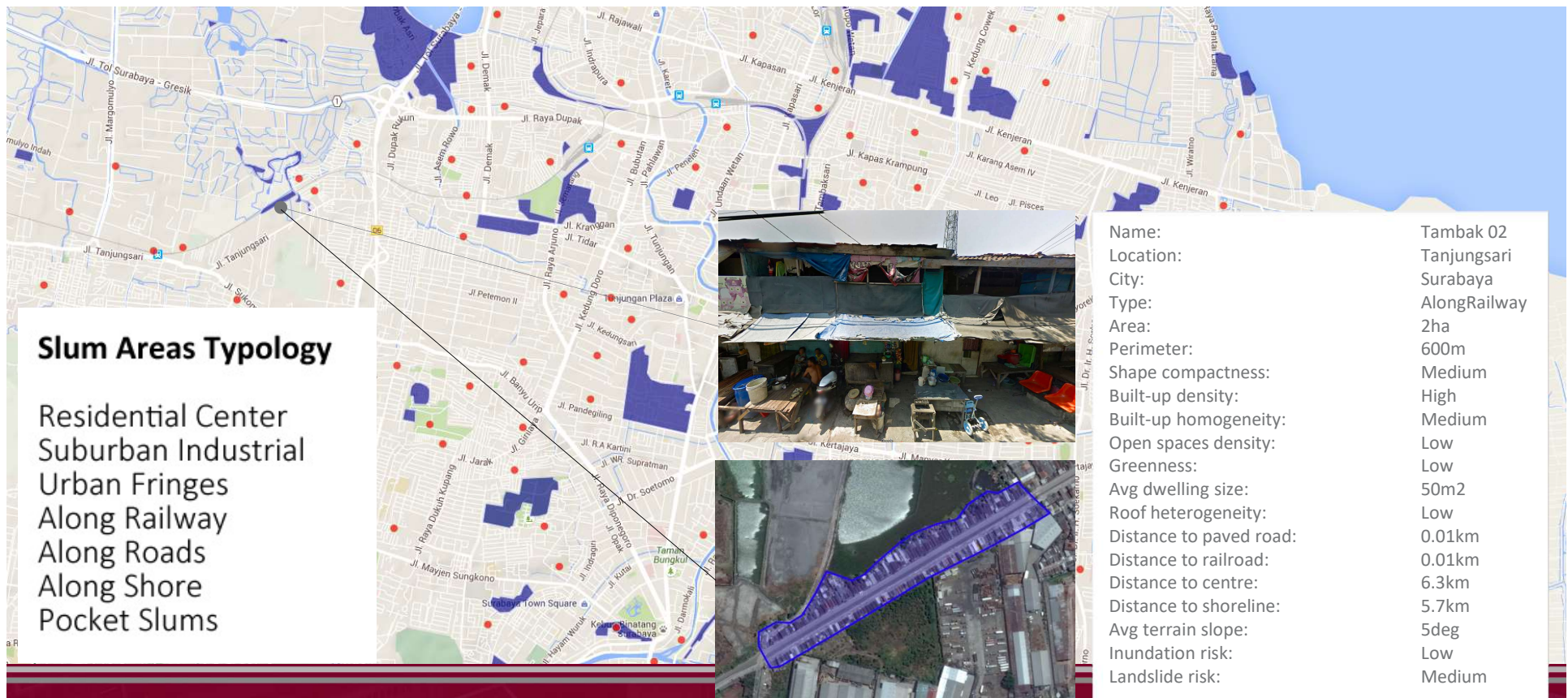




# Informal Settlements / Slums



## Slum area characterization - slum areas typology

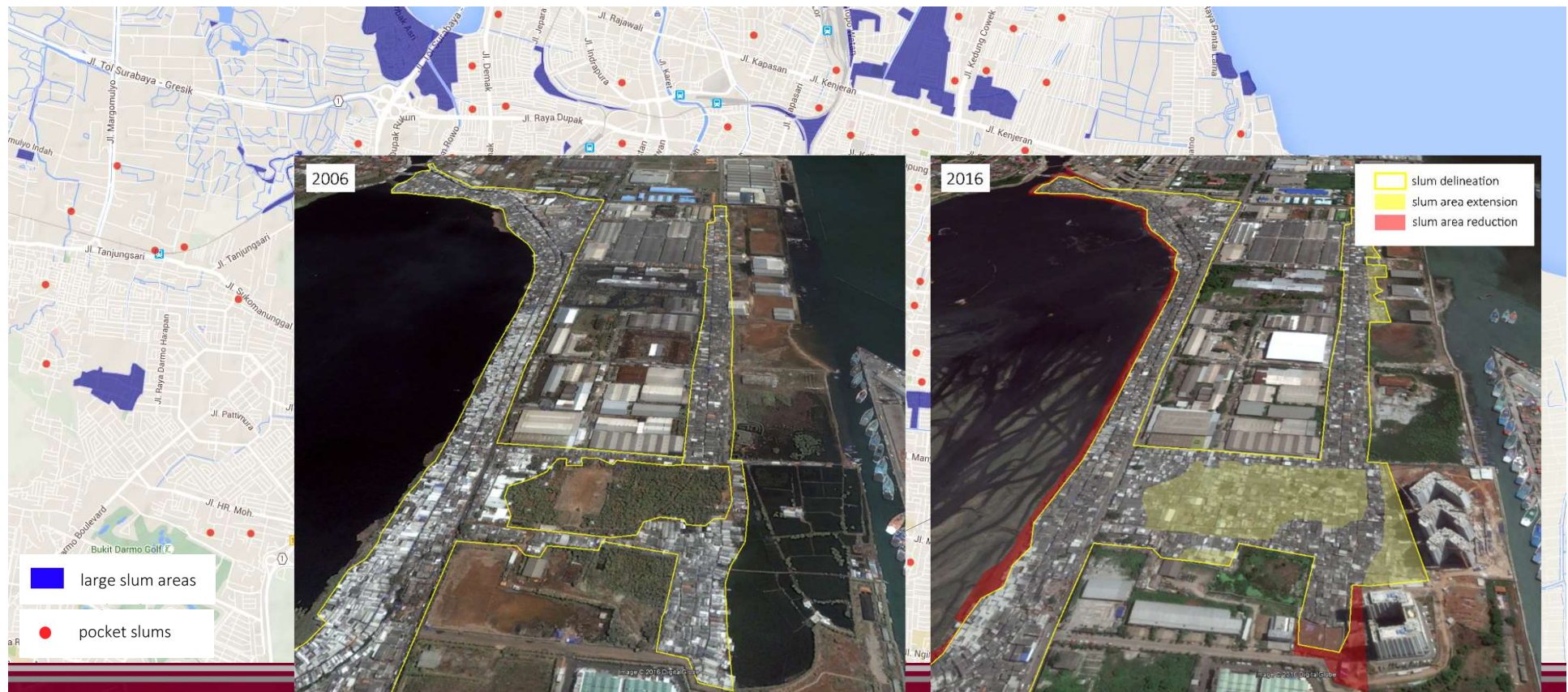




# Informal Settlements / Slums



## Slum development monitoring - change detection

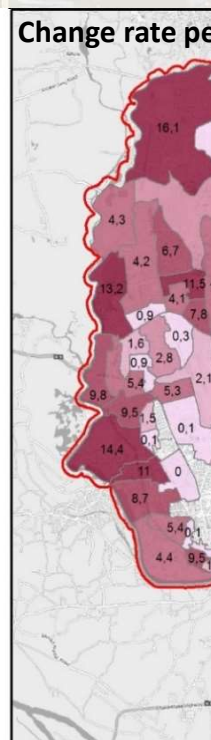
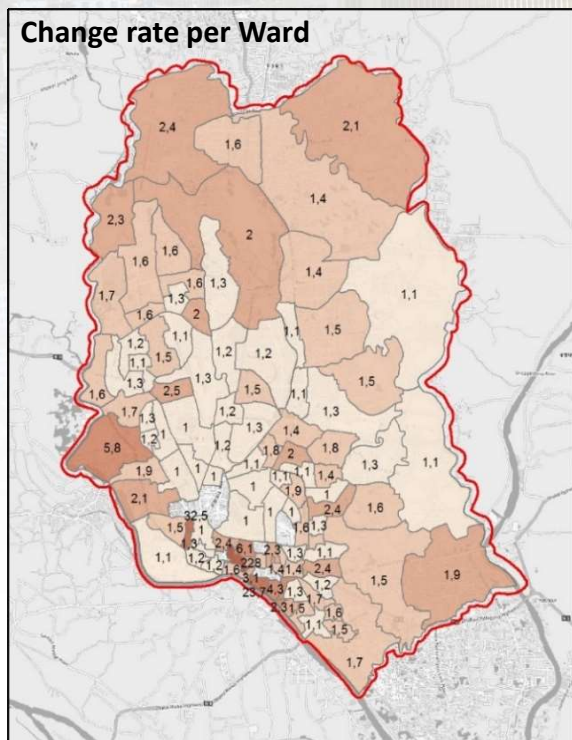




# Informal Settlements / Slums

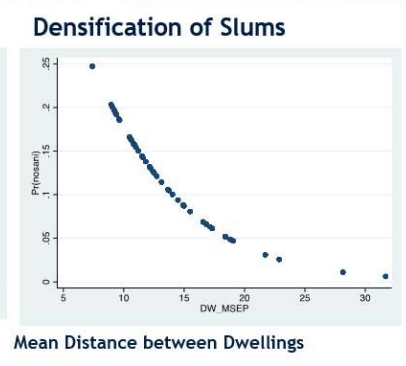
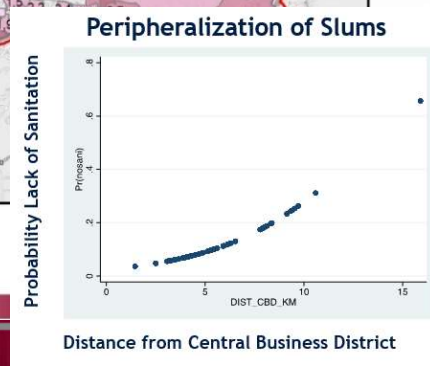


Service deprivation modelling. Beside slums identification, delineation and change monitoring, thorough characterization was done. Statistical model was trained by WASH data. Service Deprivation estimates extrapolated.



Indicator Group / Indicator	Indicator type	Input Data
<b>Neighbourhood locational</b>		
Distance to paved road	Quantitative	OSM, LULC
Distance to railroad	Quantitative	OSM, LULC
Distance to centre/CBD	Quantitative	LULC
Distance to nearest important connectivity node	Quantitative	OSM, LULC
Distance to (heavy) industry	Quantitative	LULC
Distance to shoreline (river, canal, lake or sea)	Quantitative	LULC
<b>Neighbourhood accessibility</b>		
Distance to arterial (capacity) road	Quantitative	OSM, LULC
Distance to (selected) public services	Quantitative	OSM / GPS
Occurrence of feature within X metres	Qualitative	OSM, LULC
Road network "winding index"	Quantitative	OSM
Density of road network	Quantitative	OSM
Structure of road network typology	Qualitative	OSM
Road connectivity - end point nodes	Quantitative	OSM
Road connectivity - junction point node weights	Quantitative	OSM
Road connectivity - junction point nodes	Quantitative	OSM

Indicator Group / Indicator	Indicator type	Input Data
<b>Neighbourhood shape morphological characteristics</b>		
Area	Quantitative	GIS
Perimeter	Quantitative	GIS
Shape compactness	Quantitative	GIS
<b>Neighbourhood LULC proportional characteristics</b>		
LULC structure in surroundings	Quantitative	GIS
<b>Neighbourhood internal structure</b>		
Built-up homogeneity	Quantitative	OBIA
Built-up density	Quantitative	OBIA
Open spaces density	Quantitative	OBIA
Greenness density	Quantitative	OBIA
<b>Neighbourhood dwelling characteristics</b>		
Mean dwelling size	Quantitative	Imagery
Mean dwelling separation	Quantitative	Imagery
Mean estimated dwelling height	Quantitative	Imagery
Roof heterogeneity	Quantitative	Imagery
Roof & masonry material	Qualitative	Imagery
Estimated dwelling age	Qualitative	LULC

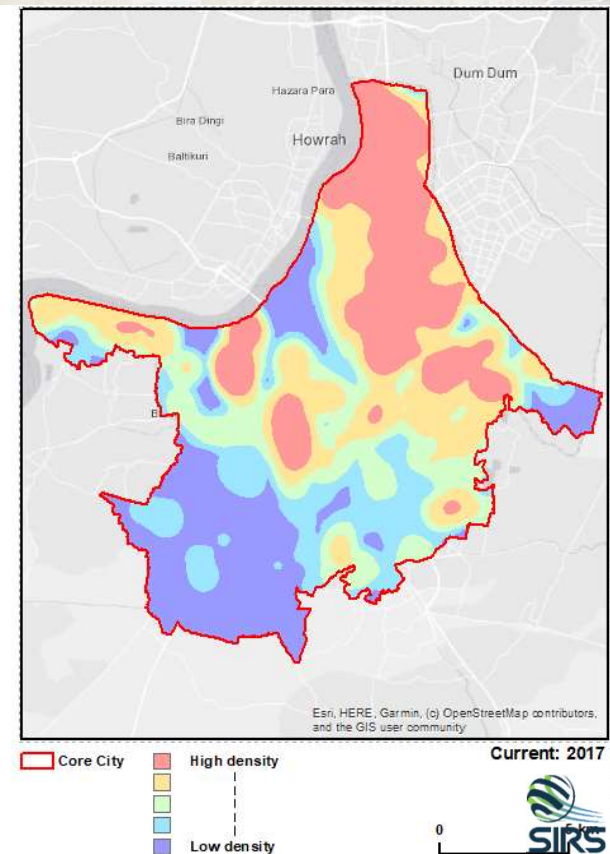
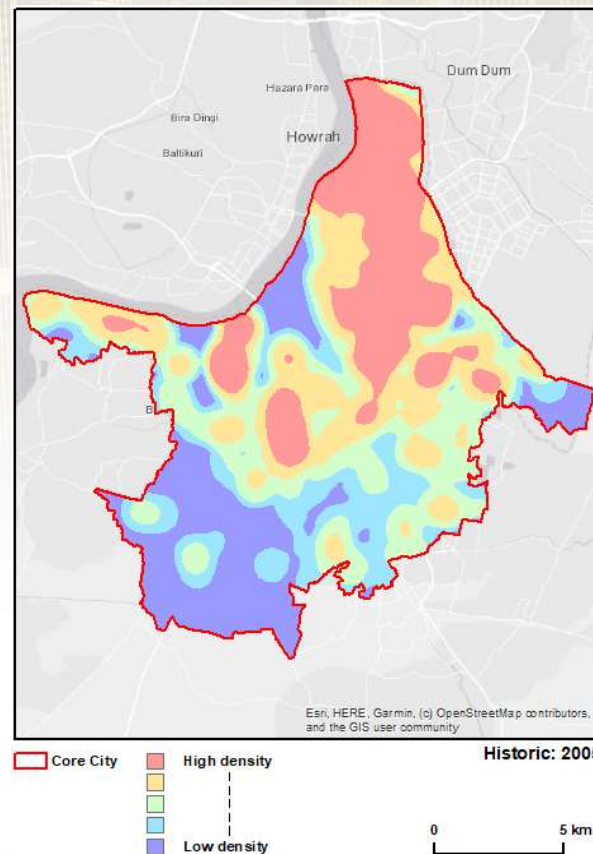
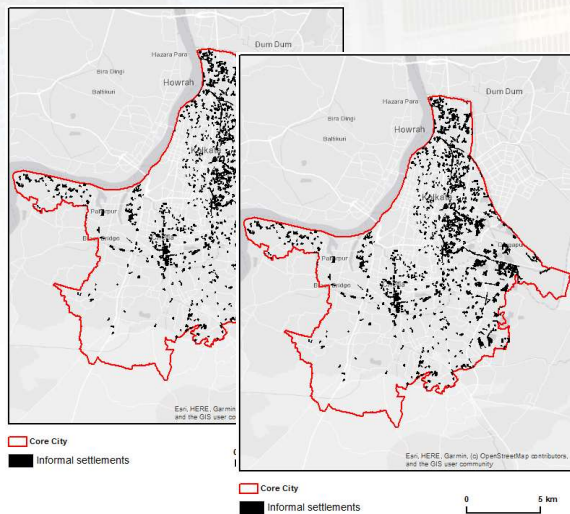




# Informal Settlements / Slums



Dispersion of Slums over the city. Built-up area extracted from the LULC product, the Informal Settlement product as well as Population census data provided by local authorities at Ward level used to locate urban population living in informal settlements.



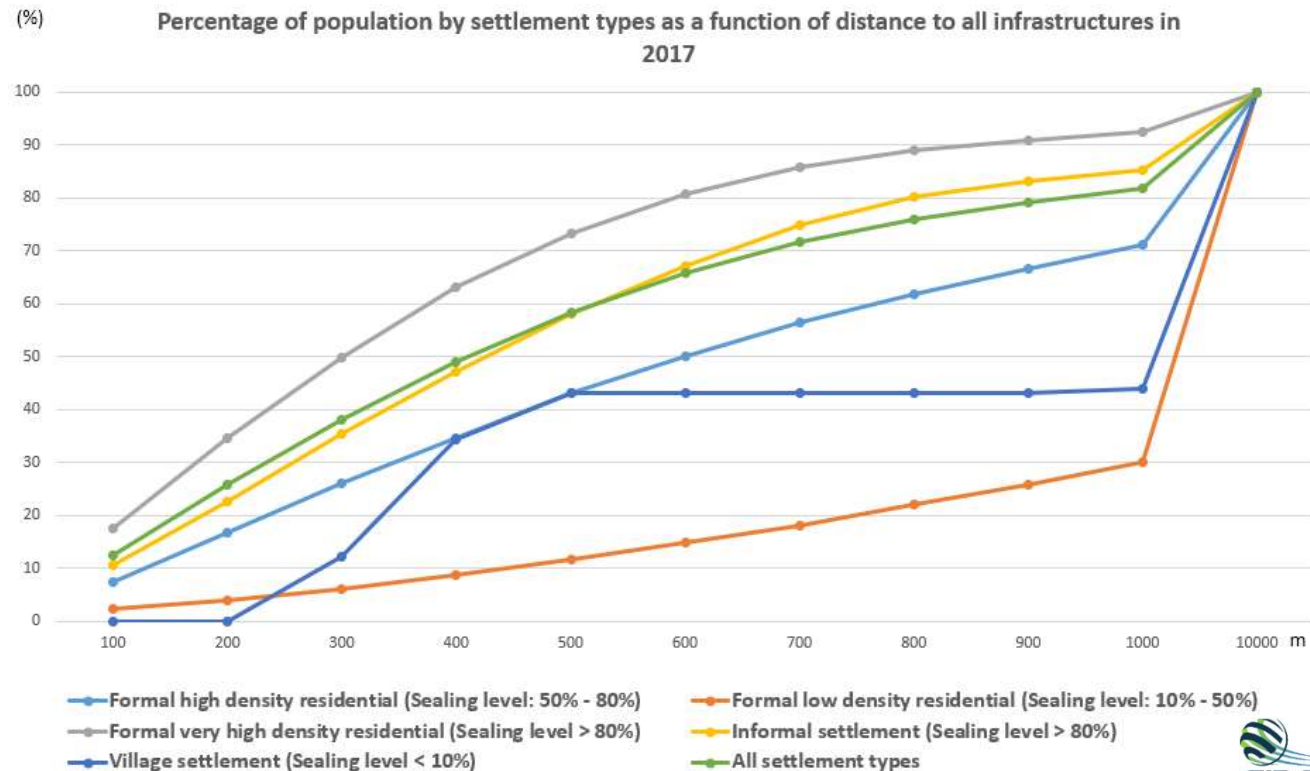
# Informal Settlements / Slums



Informal Settlements and Distance to major infrastructures indicators was calculated for the example of Kolkata. Specifically, main roads and railway stations were taken into account.

In Kolkata, the proximity of the slum population to infrastructure is comparable to that of the formal high and very high density residential.

These trends are stable over time.

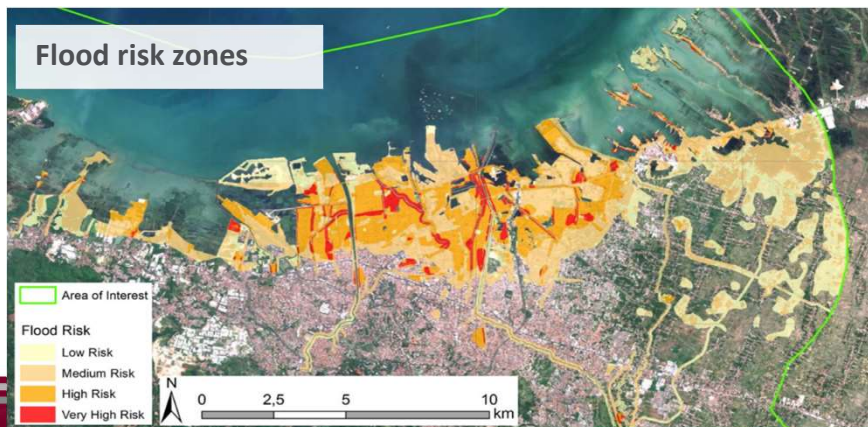
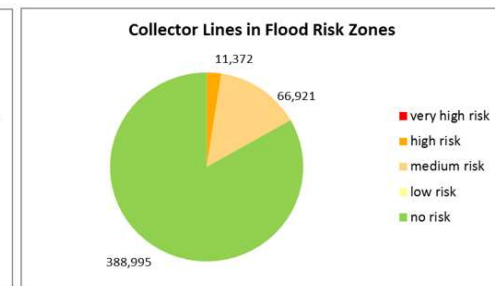
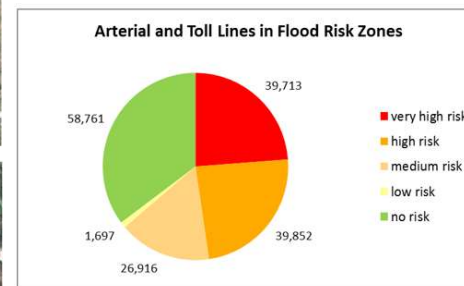
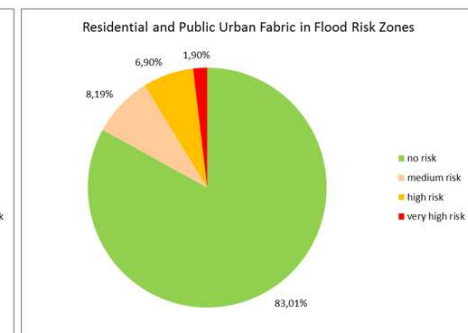
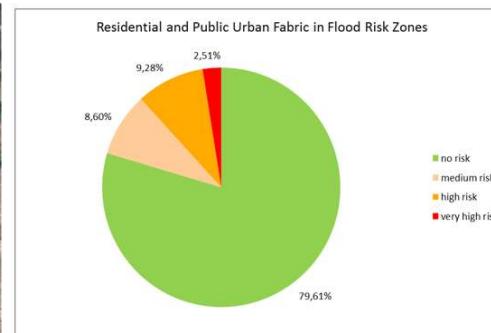
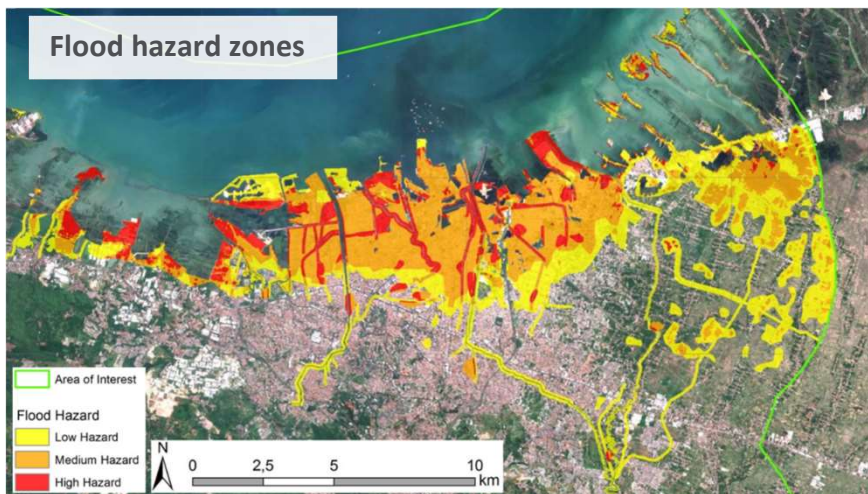




# Risk Assessment



Multiple **hazards** which put in danger the City assets, some of them boosted by Climate Change (**flood, subsidence, earthquake, landslides**)



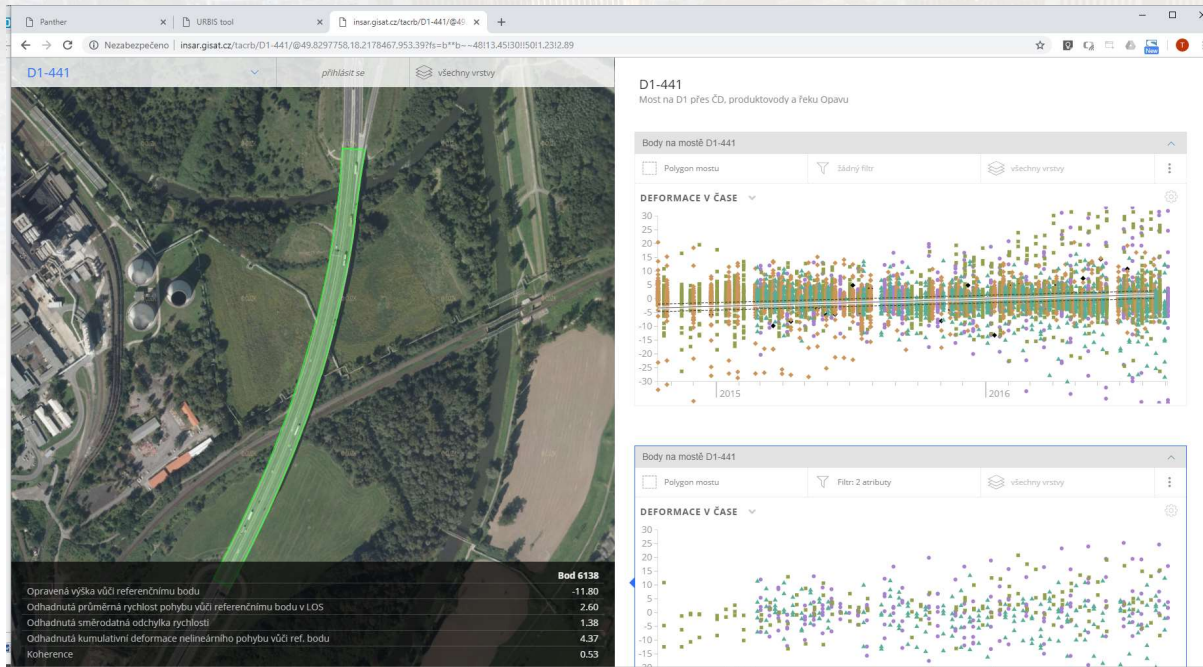
Example from Semarang for flood risk. Hazard and risk zone and base statistics of the City assets affected.



# Risk Assessment



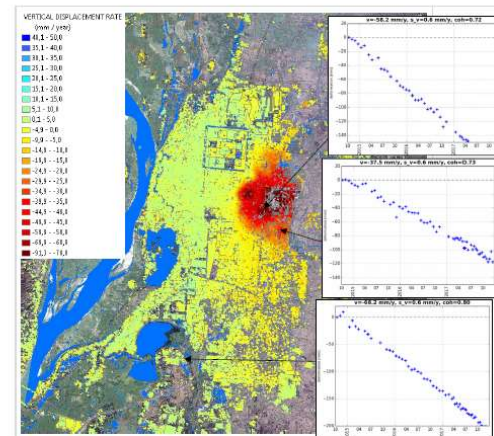
**Subsidence** monitoring on a city level (Mandalay example) or monitoring of individual buildings, road, railways, bridges, banks, dams etc.



## Monitoring of Urban Terrain Motions with InSAR Mandalay, Myanmar

To follow up on mapping and technology uptake activities conducted in frame of EOTAP-K project (2015-2016) and to increase an impact of land use mapping results derived in framework of E04SD-Urban project (2017-2020) the terrain motion map has been derived by GISAT by means of interferometric persistent scatterers technique (PS InSAR) for Mandalay city area.

Results based on analysis of 3-year long time series (2015-2017) of SAR imagery from European Sentinel-1 satellite identify significant and disturbing pattern of probably vertical terrain displacement (land subsidence) in the area east of the city centre. The pattern with relatively regular shape reveals zone with potential serious geological / tectonic hazard to affected assets and population. Mean downward annual vertical displacement rates for detected persistent scatterers exceed 5 cm / year in the central part of elliptical pattern. In other words, this area has subsided by more than 15 cm in the last three years. Questionable is when the process of subsidence had commenced. Anyway, such a high displacement rate may possess a serious risk of structural damage to exposed buildings.



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# Conclusion

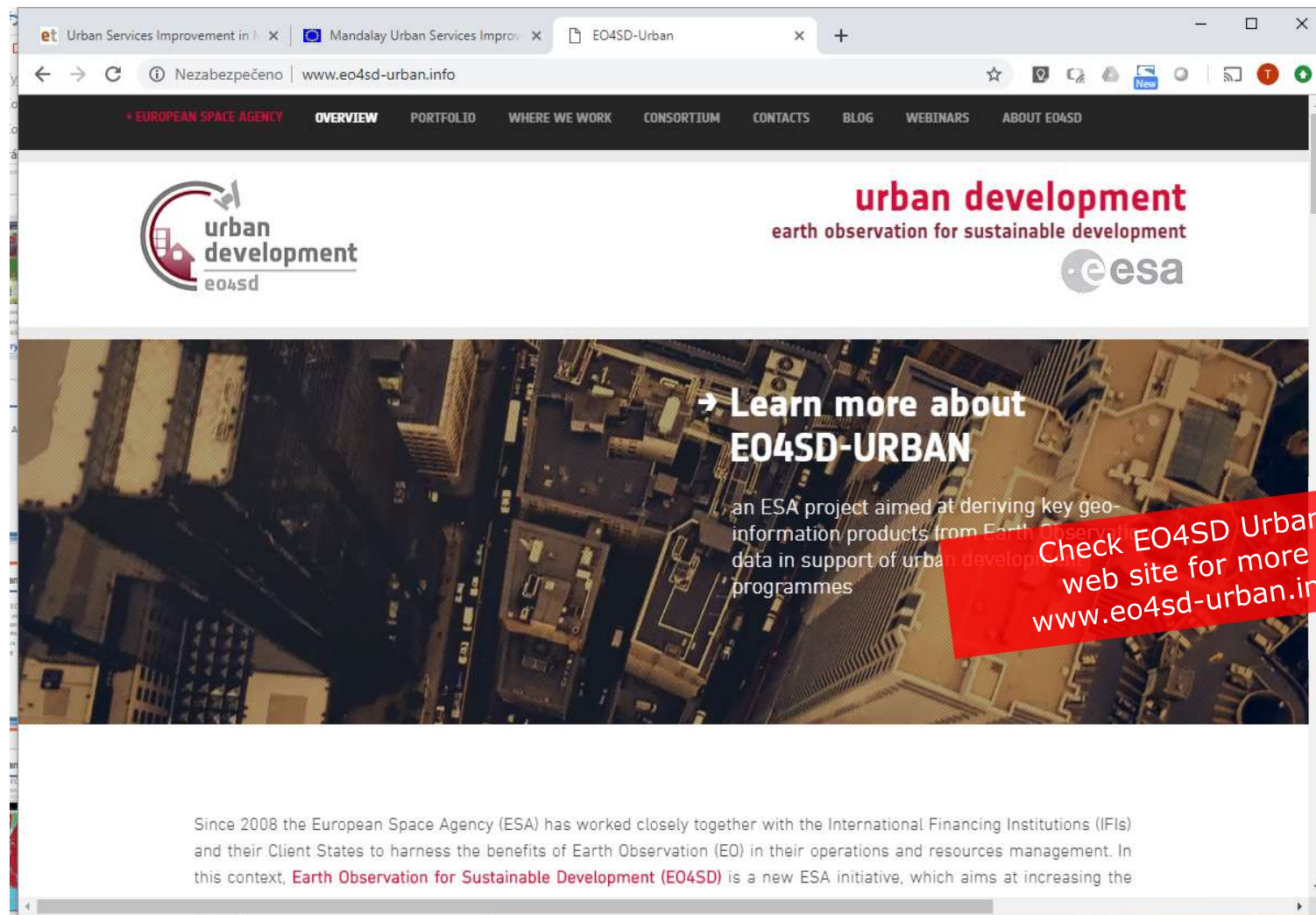
EO4SD Urban EO-products are based on:

- Verified user requirements
- Harmonised and standardised state-of-the-art methodologies
- Comprehensive and transparent documentation
- Application of statistically sound accuracy assessment
- Stringent Quality Control to ensure:
  - transparency
  - repeatability
  - completeness
  - validity
- User feedback welcomed to improve the services



# More Resources

# More Resources





# More Resources



The screenshot displays the Urban Development Explorer web application. The browser address bar shows the URL: <https://urban-tep.eu/puma/tool/?id=82929&lang=en&needLogin=true#>. The application interface includes a top navigation bar with 'Portal', 'Support (Redmine)', and 'Video Help'. Below this is a toolbar with options like 'Place', 'Mandalay', 'Theme', 'Land Cover Land Use', 'Periods', '2016', 'Visualization', and 'LULC structure - detail'. The main map area shows a city layout with a red rectangular selection box. On the left, a 'Layers' panel lists various data layers, including 'Analytical Units Layers', 'Thematic Layers', 'Info Layers', 'Land Cover Land Use', 'Urban Green', 'Floods', and 'Background layers'. On the right, there are three data visualization panels: 'Areas 1 - 11 of 11' (a bar chart), 'Structure of urban fabric [%]' (a stacked bar chart), and 'Urban fabric vs. Indus., Comm., Transp. vs. Artificial land' (a pie chart). A red banner with white text is overlaid on the bottom right of the screenshot, reading: 'Web Exploration Tool available at <https://urban-tep.eu>'.

Thank you for your attention!

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