Agenda and Speaker

Remote Sensing for Cities Support on the Ground

Analytics and Spatial Indicators: EO4SD-Urban Experience

Speaker

Tomas Soukup

Remote Sensing Consultant
GISAT, Czech Republic

Outline of the Presentation

- Context
- Level of support
- Products and Analytics and Indicators examples
- Conclusions
- Announcement

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

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:

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

Urban Development Agenda

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- **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

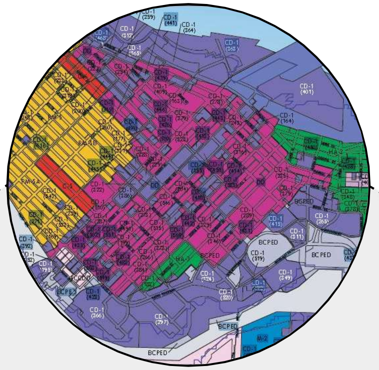
These challenges and opportunities are reflected and embedded in the UN Sustainable Development Goals (SDGs)

ESA EO4SD Urban Project addresses both by services providing multi-scale dedicated EO based information support

Cities are complex, so the knowledge needed. Location is a key for integration

ACTORS
Planners
Local Govt.
Investors
Developers
Communities
Users

MACRO
Economy
Population growth
Real estate cycle
Space demand



GOVERNANCE
Policies & regulations
Zoning & FARs
Risks

Evidence-based planning with reliable and trackable data

URBAN FORM
Extent
Density
Land Assets
Urban Design
Evolution
Typology
Public Space
Transportation
Services
Engineering

PUBLIC LIFE/PEOPLE
Culture
Health
Safety
Recreation
Livelihoods
Mobility
Inclusion

Urban Planning and Earth Observation

Urban planners need answers on many spatial-related questions like:

- What defines our city?
- How is the city arranged spatially?
- How is the dynamics of changes over time?
- What is the life quality in different neighborhoods?
- How many people live there?
- How they access to basic services?
- Are they in risk?

Earth Observation has the unique capability to support 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**.

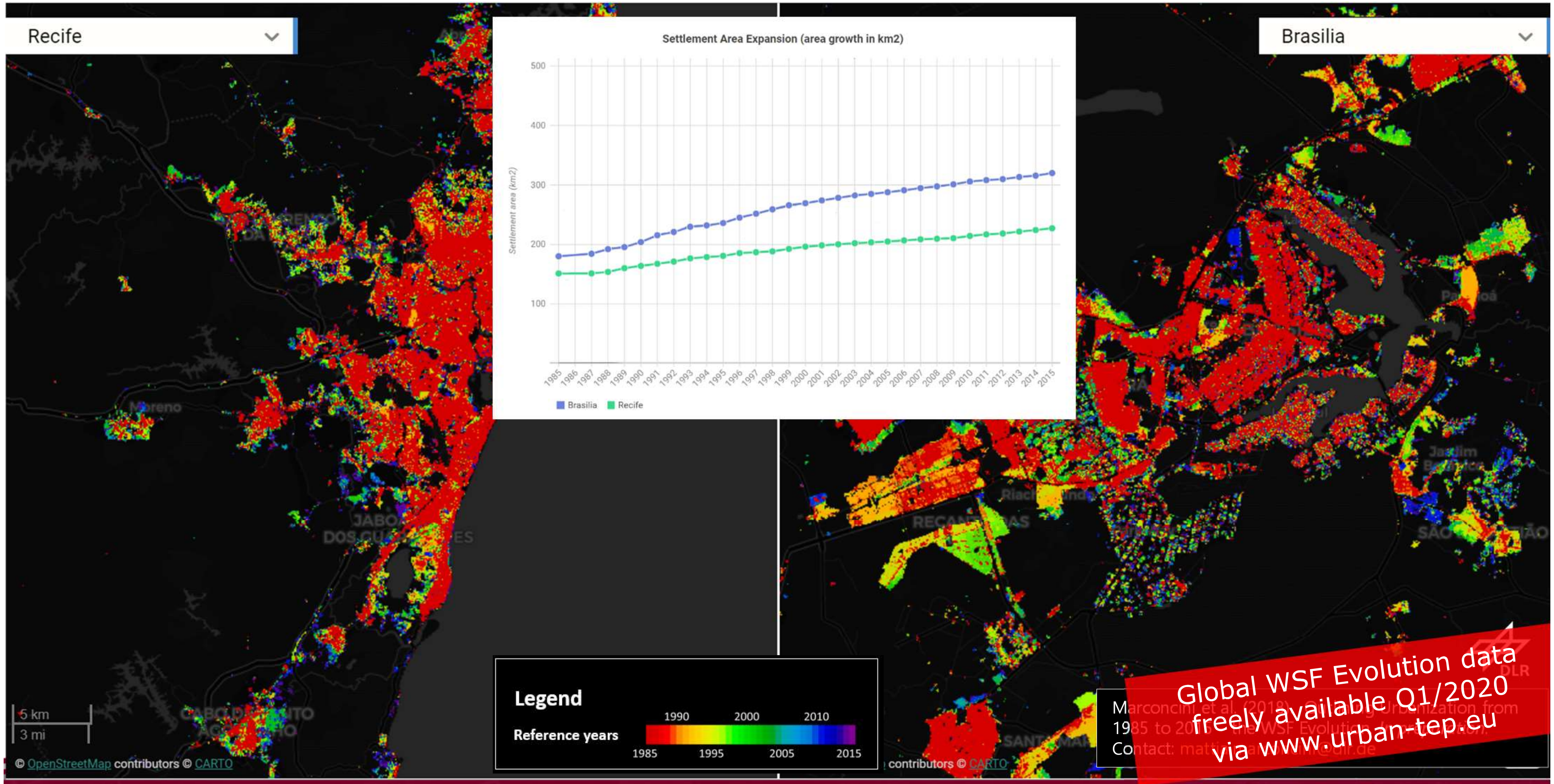
Earth Observation supports on various levels

Strategic	City diagnostic
	Strategical planning
	Hot-spots identification
	Action prioritization
Operational	Operational action design
	Public consultation and transparency
	Implementation support
	Impact monitoring

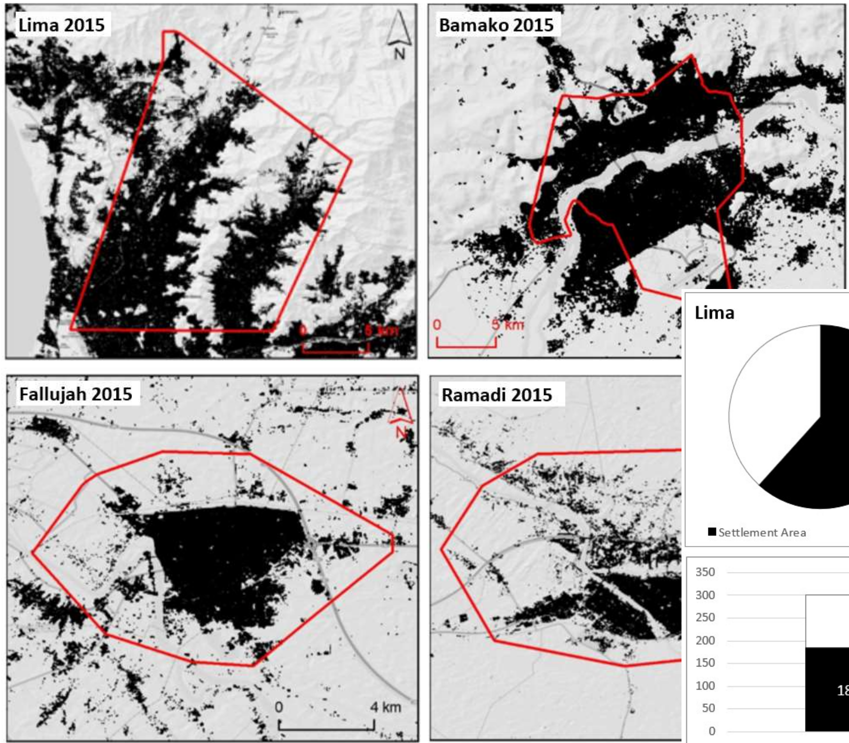
Actual potential for EO support depends very much on a local situation and capacity of a particular city

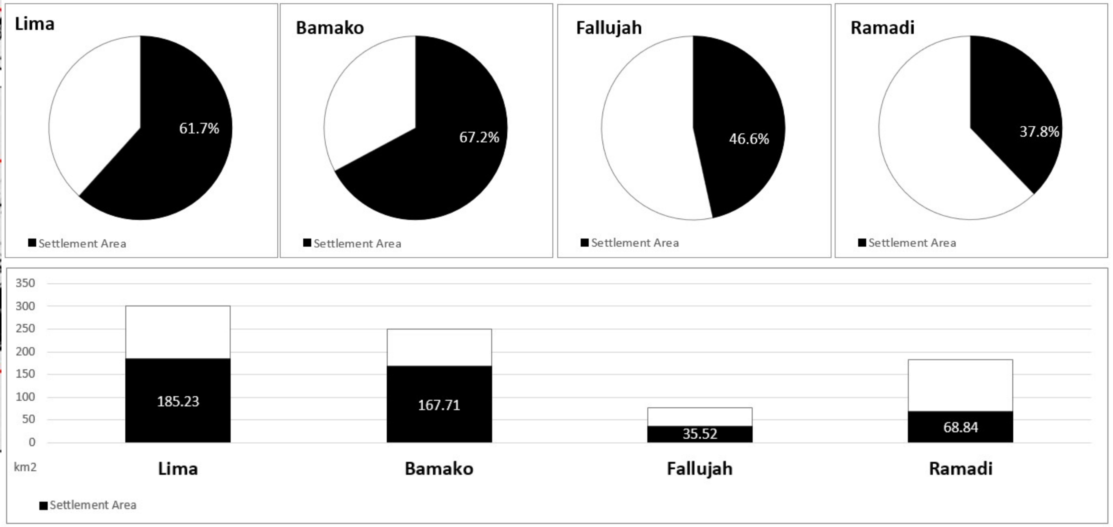
We work with partners to go beyond pixels and prepare and deliver information in a more tailored from of Indicators or/and Analytics

Understanding global urbanisation trends in last 30 years

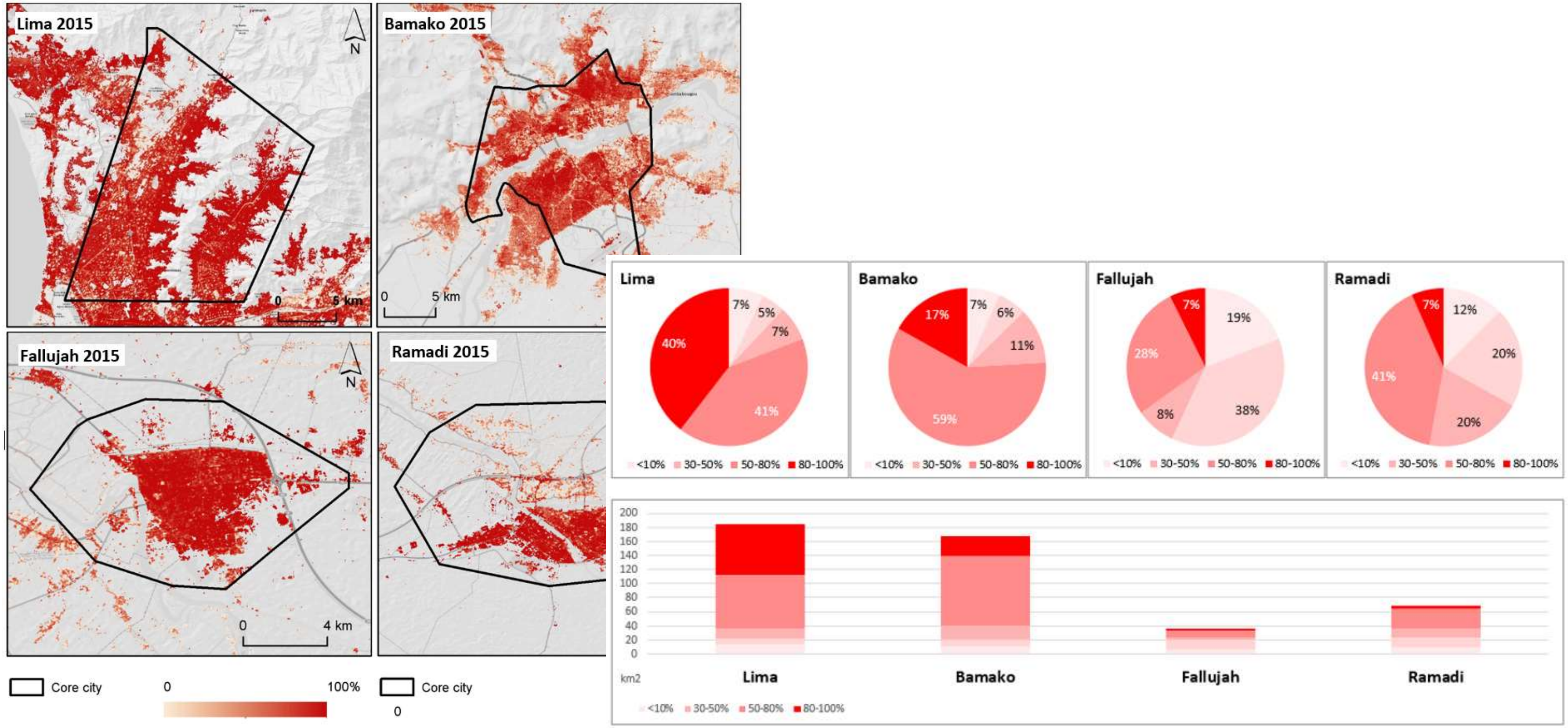


Amount and distribution of built-up area



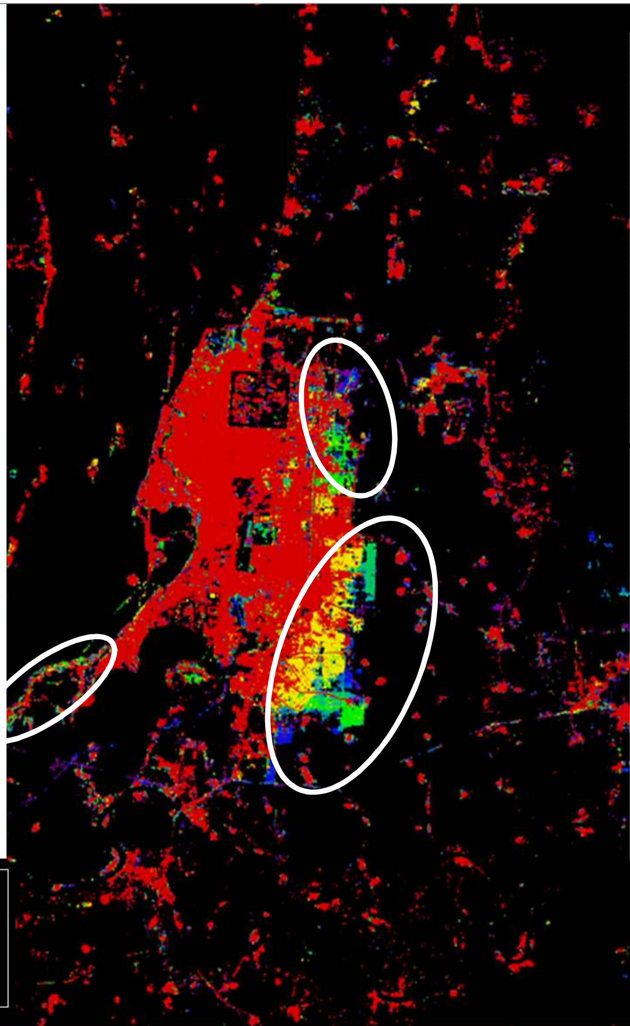


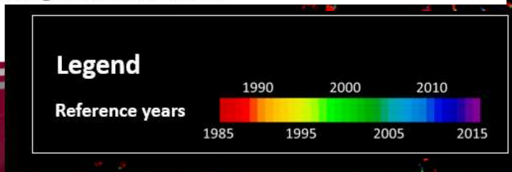
Sealing levels (aka level of imperviousness) distribution

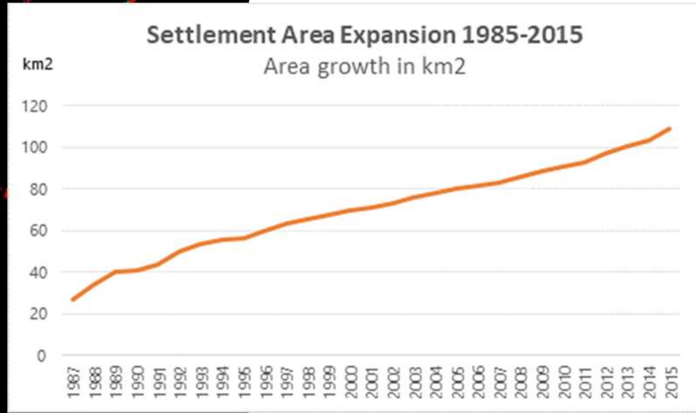


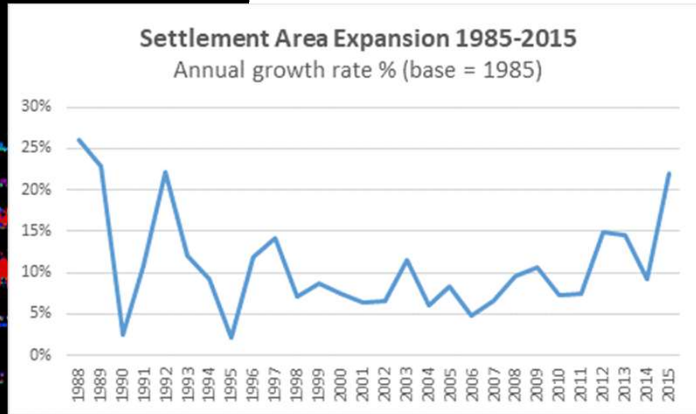
Change dynamic axes / corridors of development

Source: Mandalay Urban Development Conceptual Plan, MOC



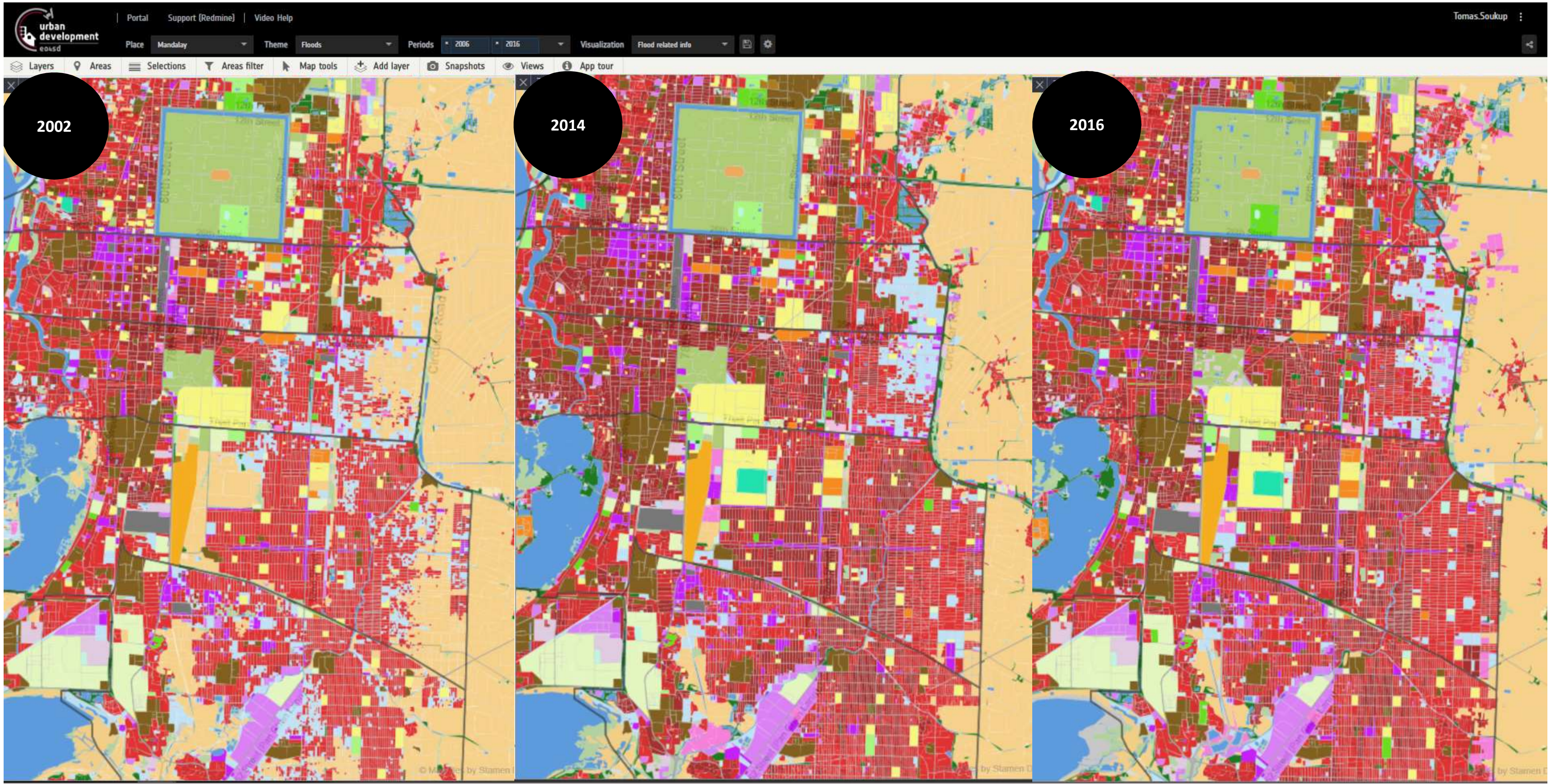






Strategic / Operational Level Support
Land Assets Management

Understanding City potential and limitation regarding land assets



Strategic / Operational Level Support
Land Assets Management

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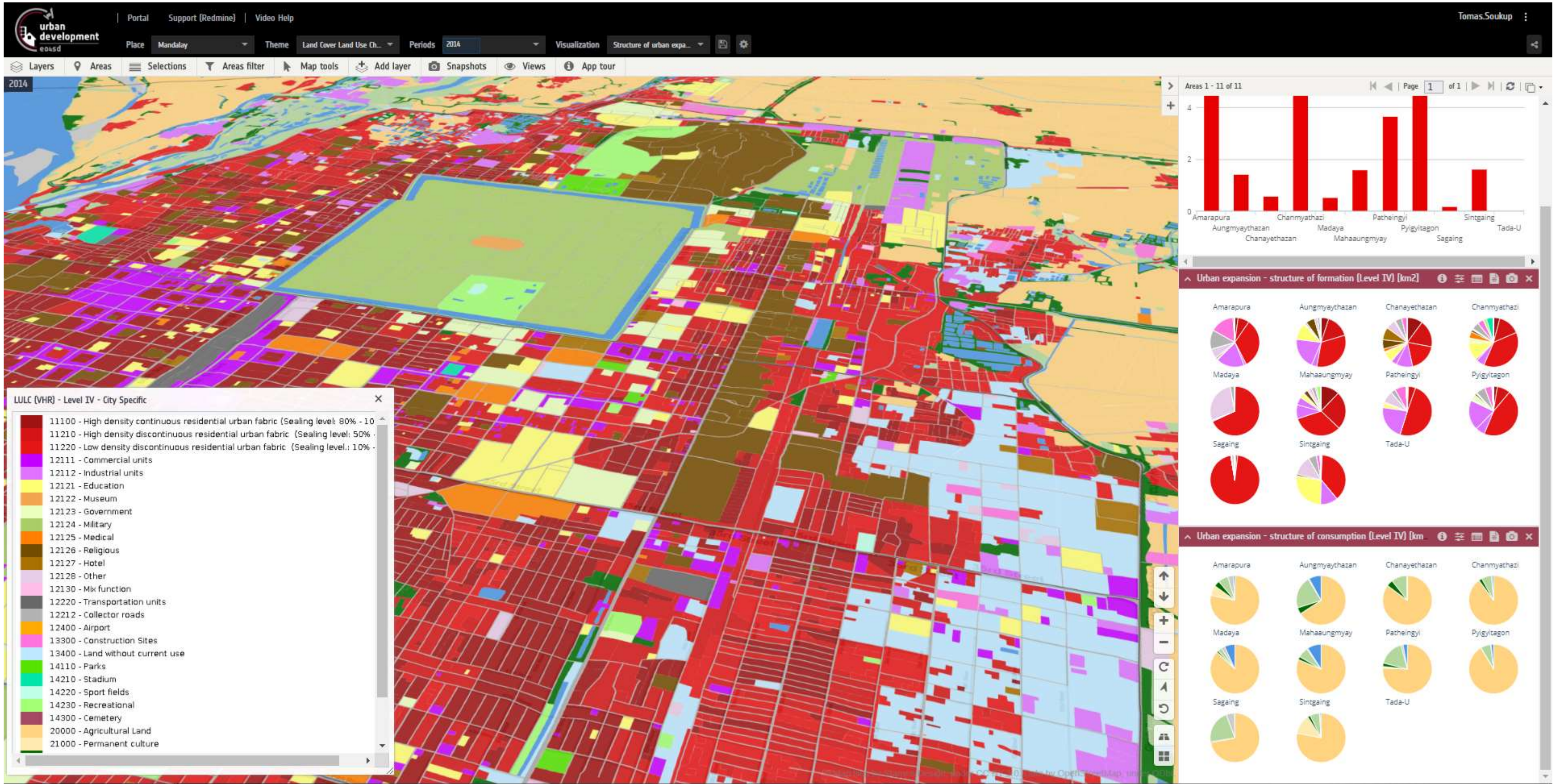
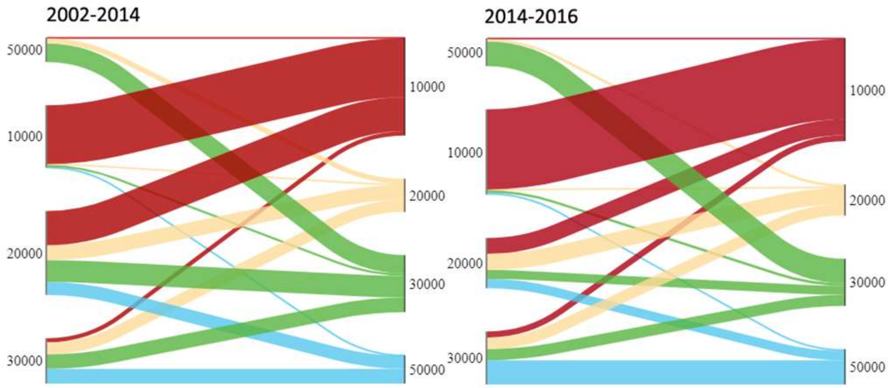
Land Assets Statistics – Where, What, Quantity & Quality



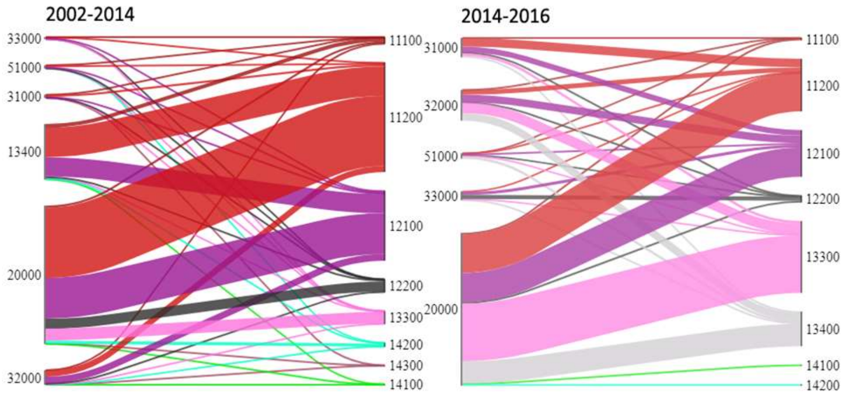
Strategic / Operational Level Support
Land Assets Management

Land Assets Statistics – Land Flows and Trends

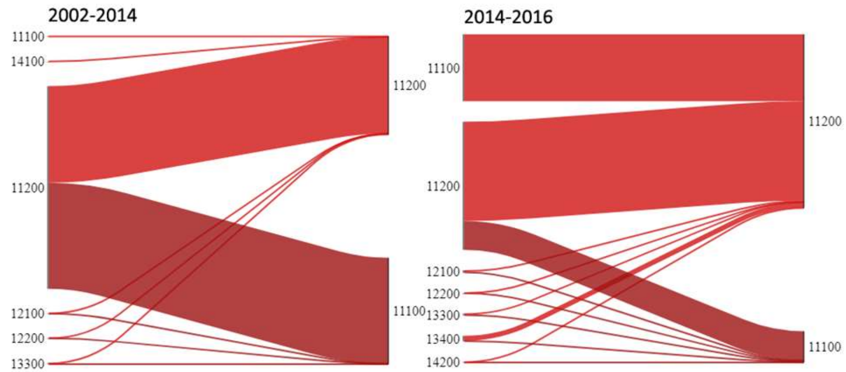
Mandalay (Myanmar) - Land Cover Flows Analysis - Overall



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



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



LULC (VHR) - Level IV - City Specific

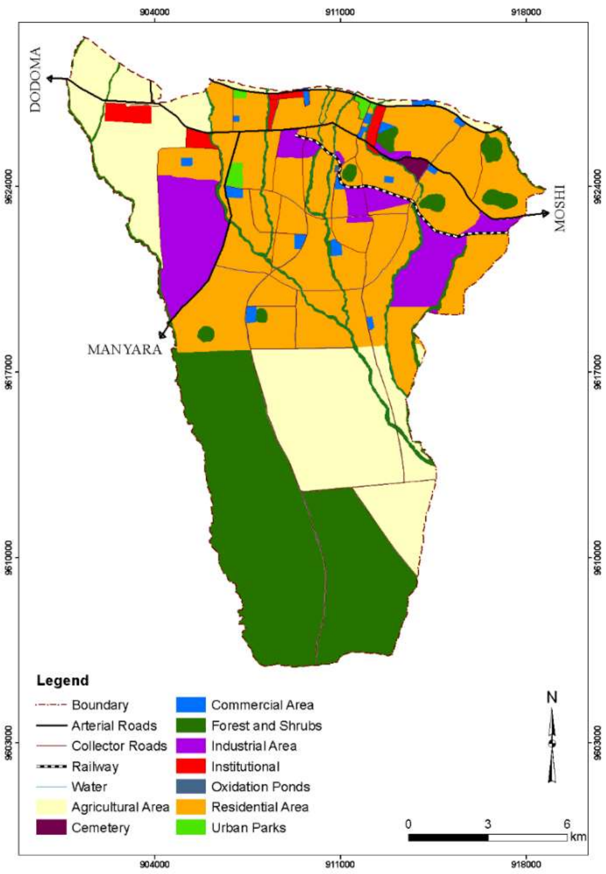
- 11100 - High density continuous residential urban fabric (Sealing level: 80% - 10
- 11210 - High density discontinuous residential urban fabric (Sealing level: 50%
- 11220 - Low density discontinuous residential urban fabric (Sealing level.: 10% -
- 12111 - Commercial units
- 12112 - Industrial units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

Strategic / Operational Level Support
Land Assets Management

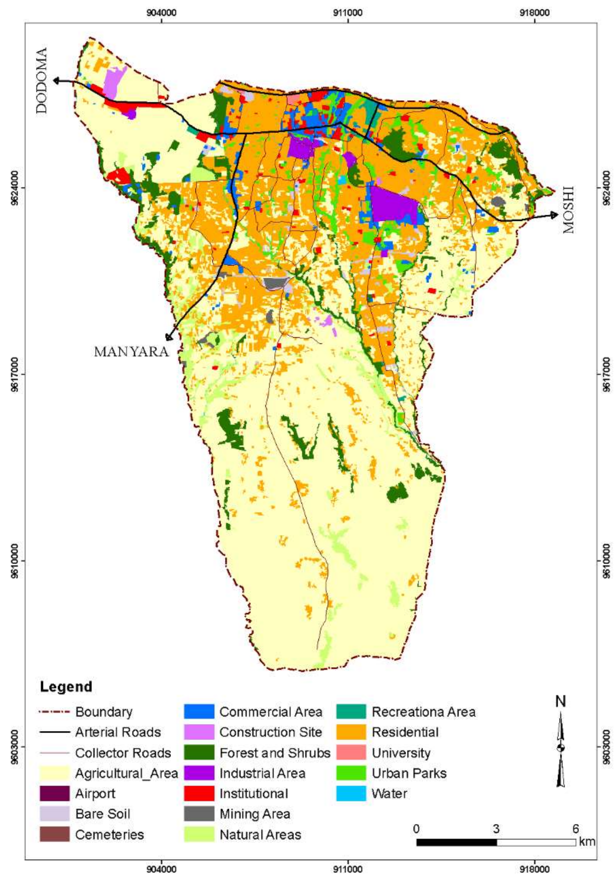
Master Plan Reality Check

Arusha, Tanzania

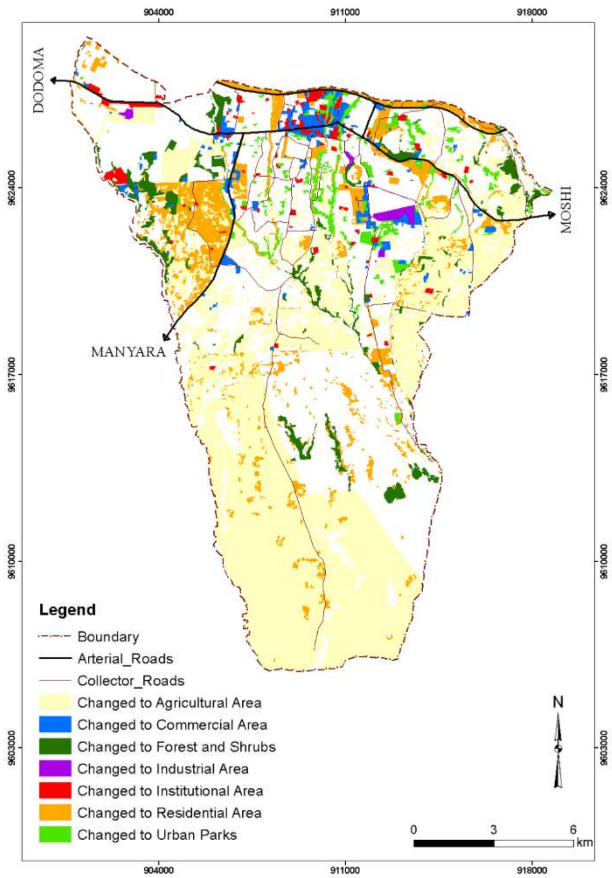
1985 Master Plan



2015 Actual Land Use

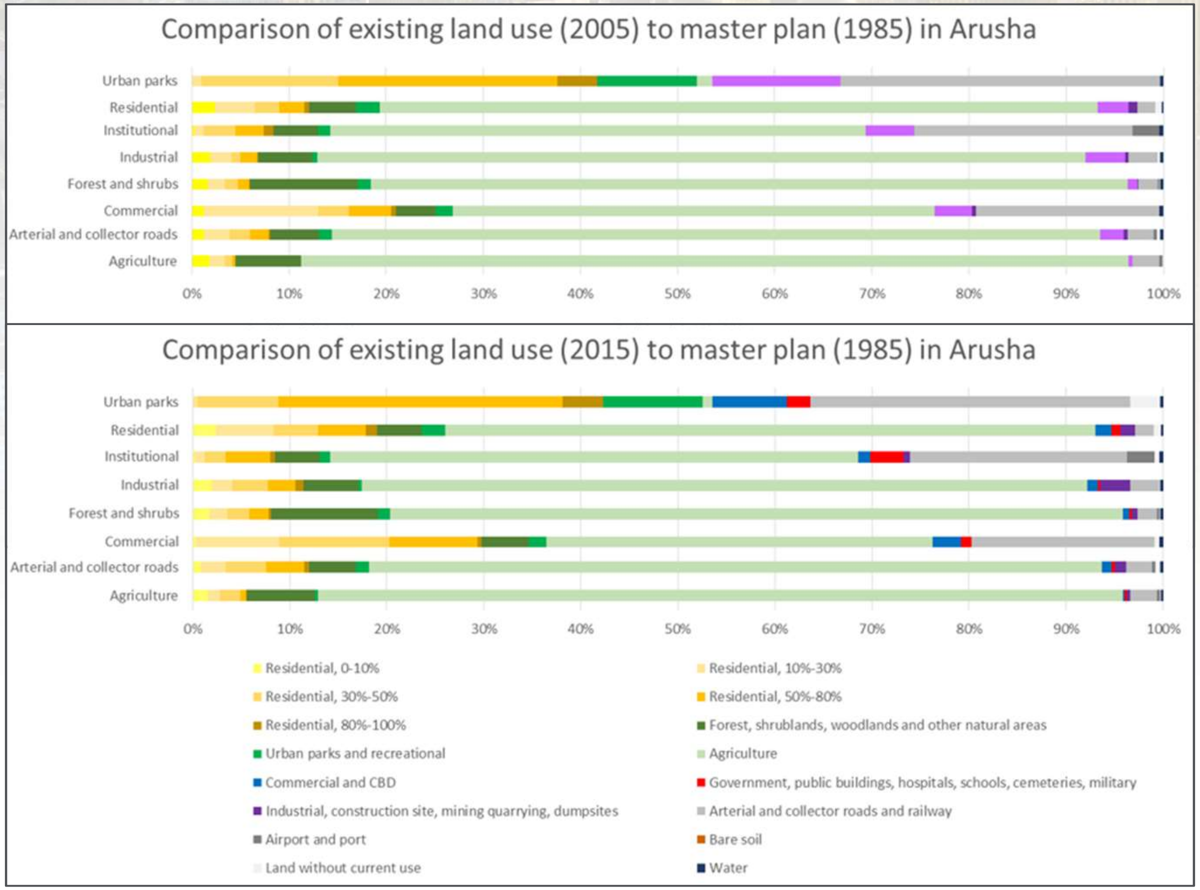


Diversion from proposed land use



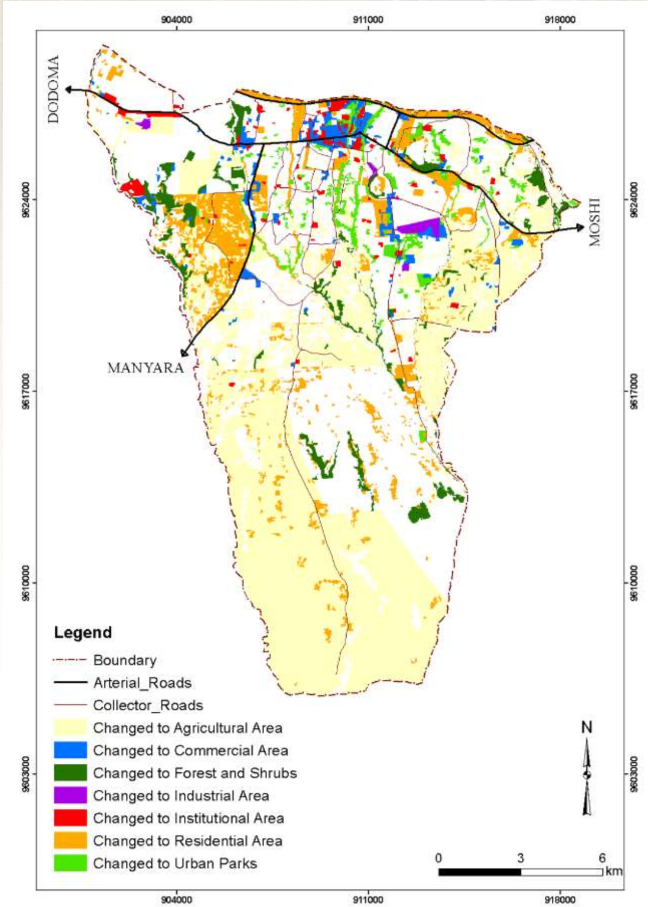
Strategic / Operational Level Support
Land Assets Management

Master Plan Reality Check

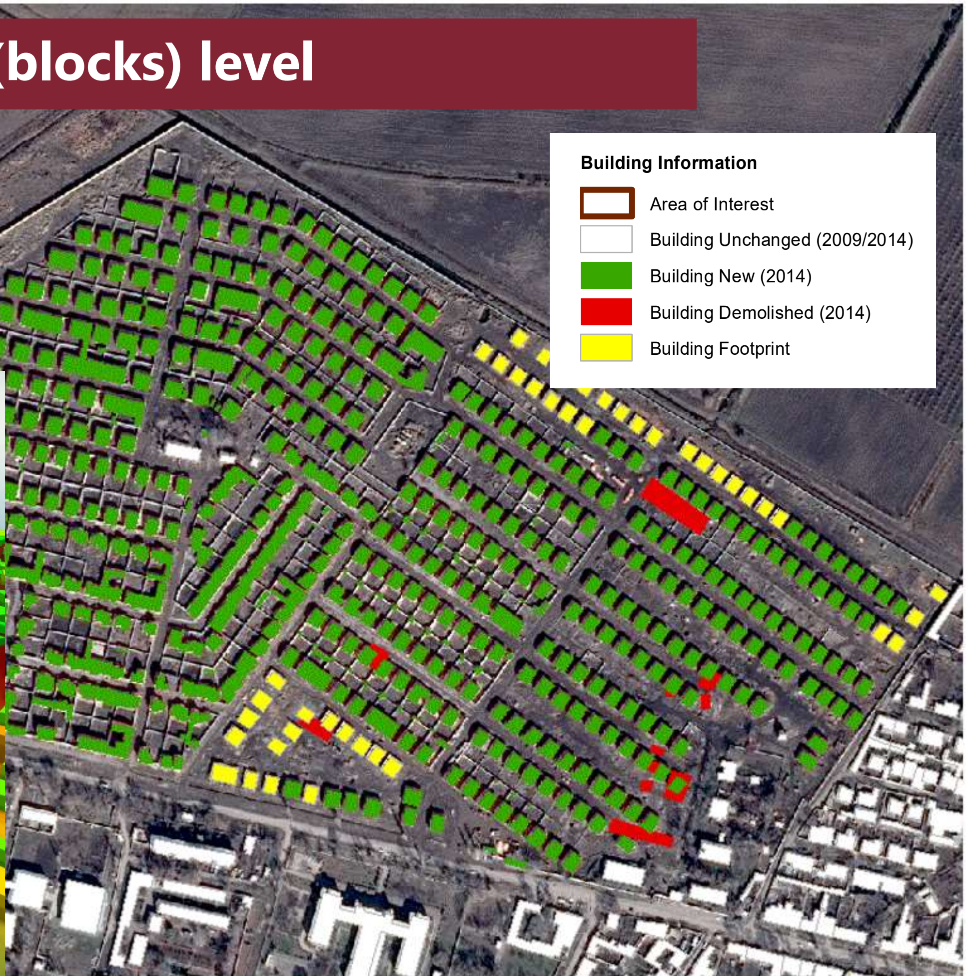


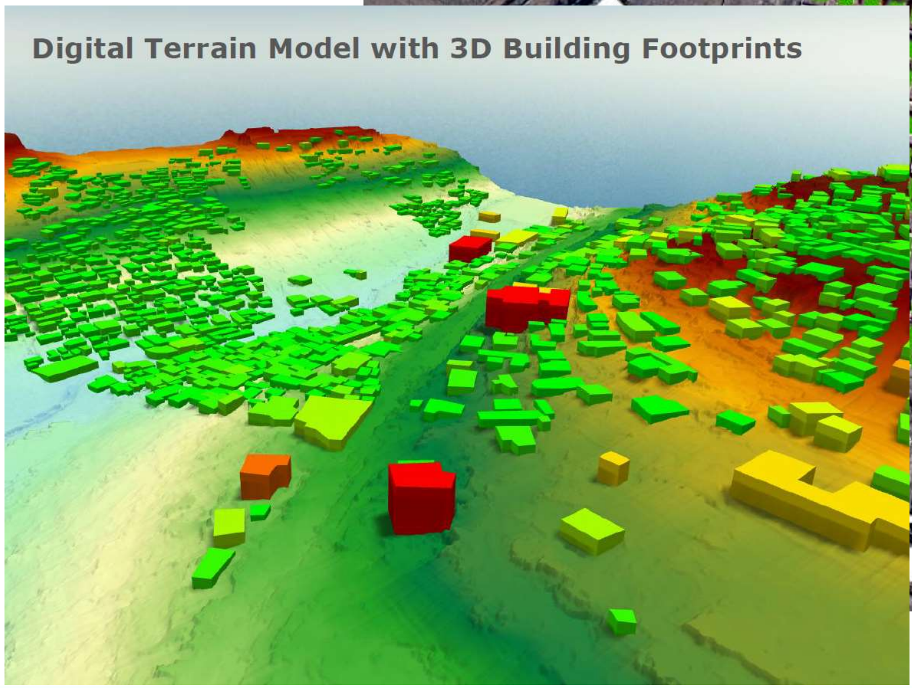
Source: Huang, C.Y. et all (2018): Translating Plans to Development, World Bank Group.

Diversion from proposed land use



Detailed information on building (blocks) level





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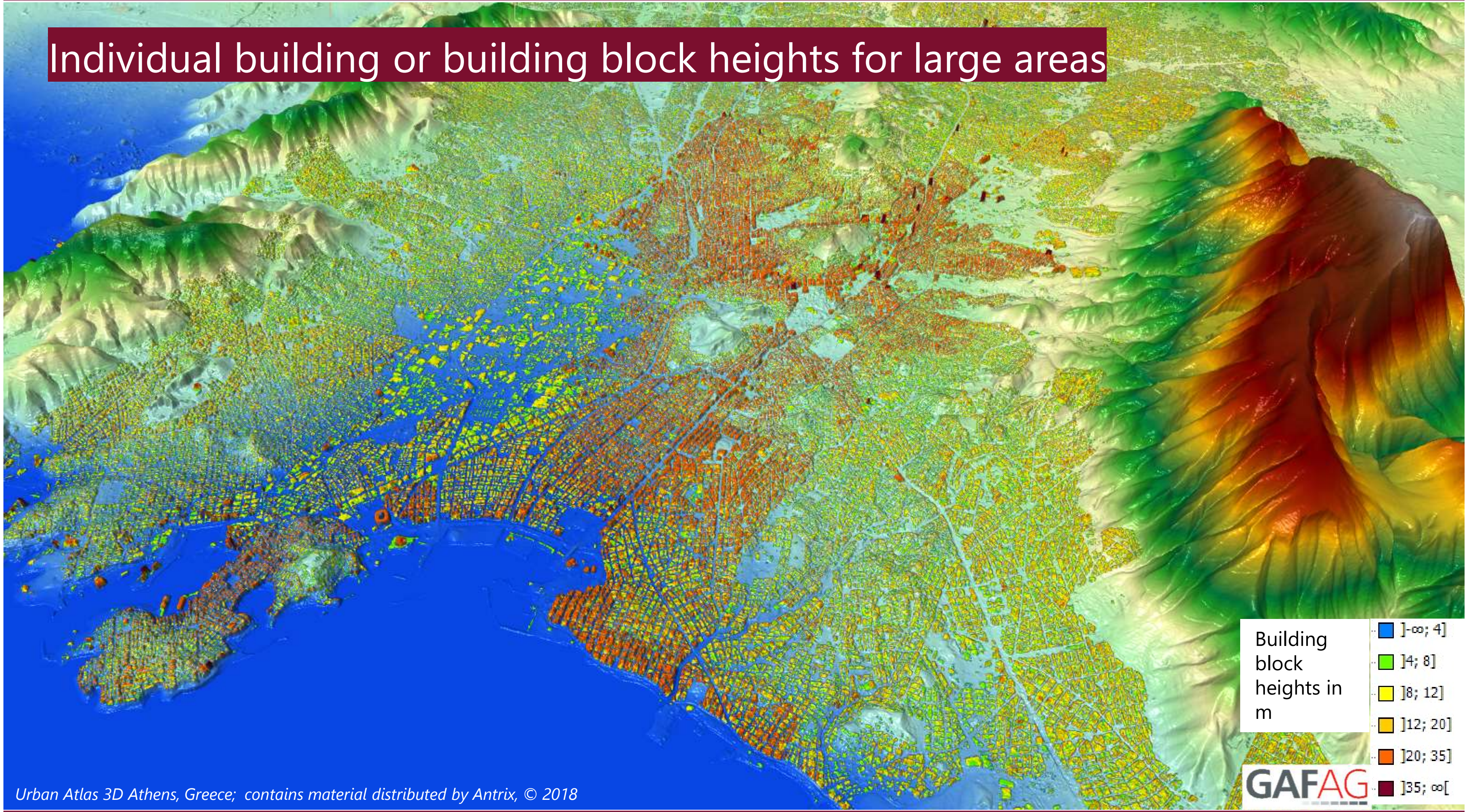
Operational Level Support
Building Footprint

Structural indicators on individual buildings level

Operational Level Support
Building Footprint

Individual building or building block heights for large areas

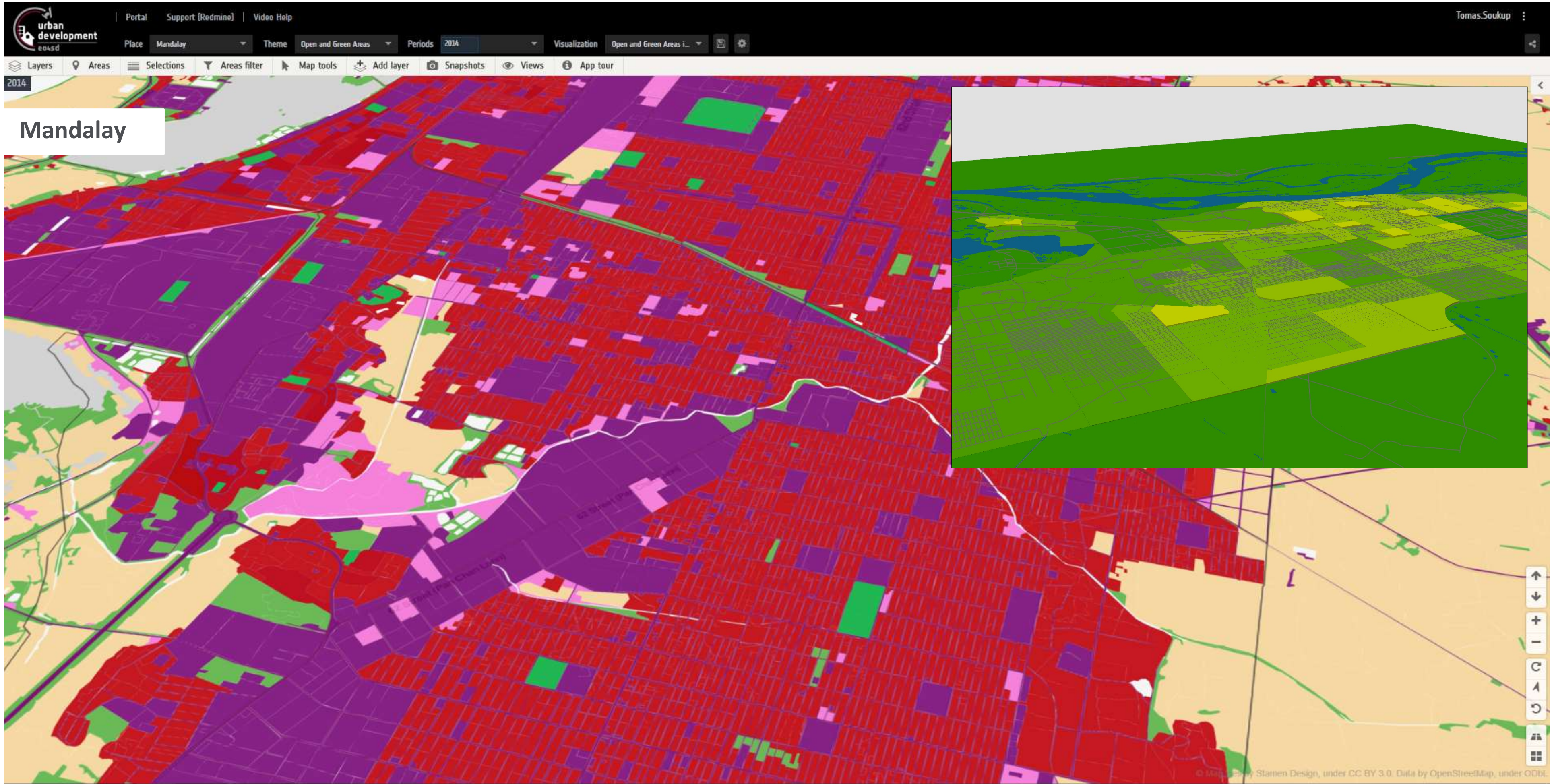


Urban Atlas 3D Athens, Greece; contains material distributed by Antrix, © 2018

Operational Level Support
Population Distribution / Density

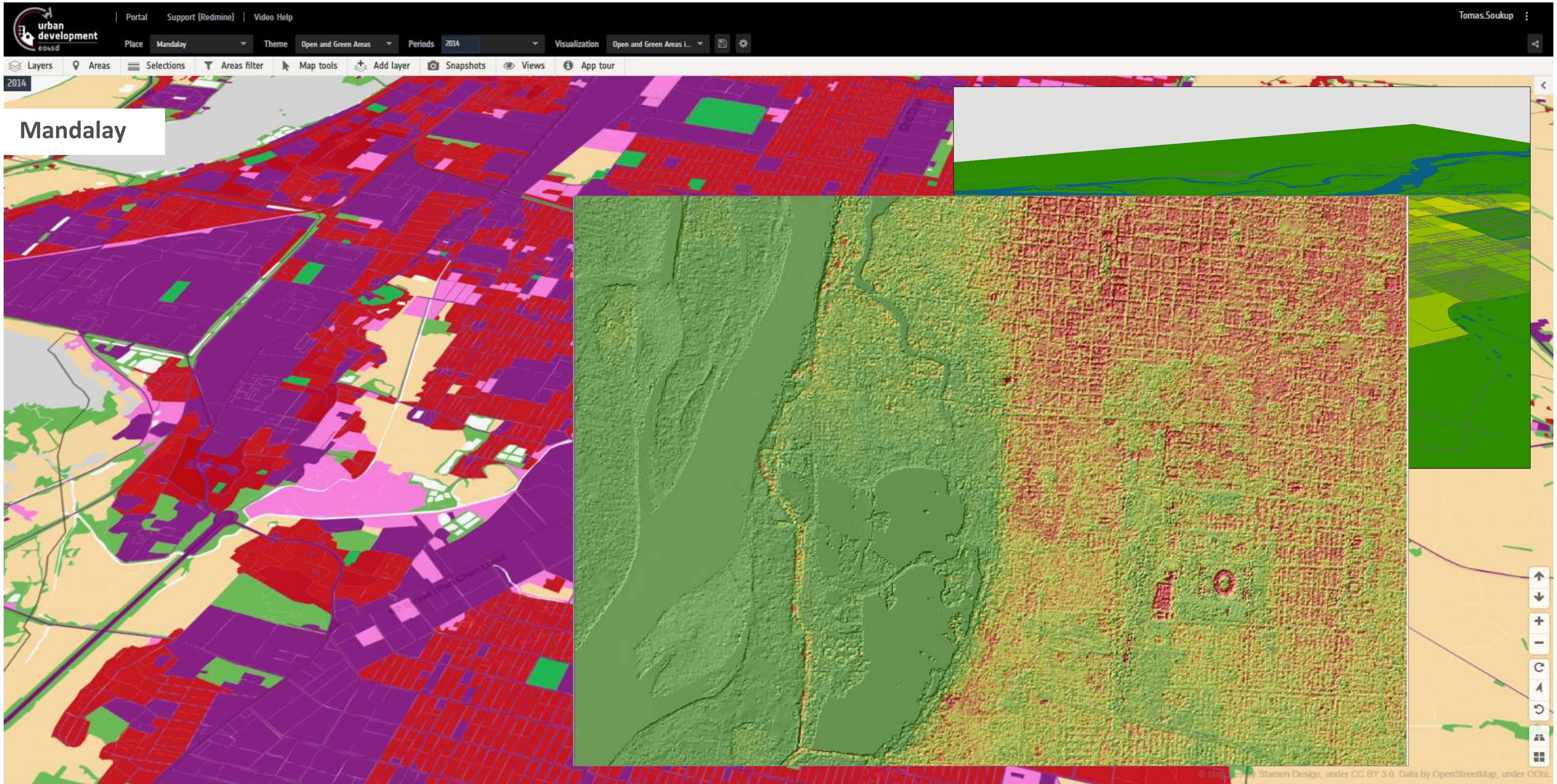
LULC, Census Data and VHR DSM for urban blocks

LULC, Census Data and VHR DSM for urban blocks



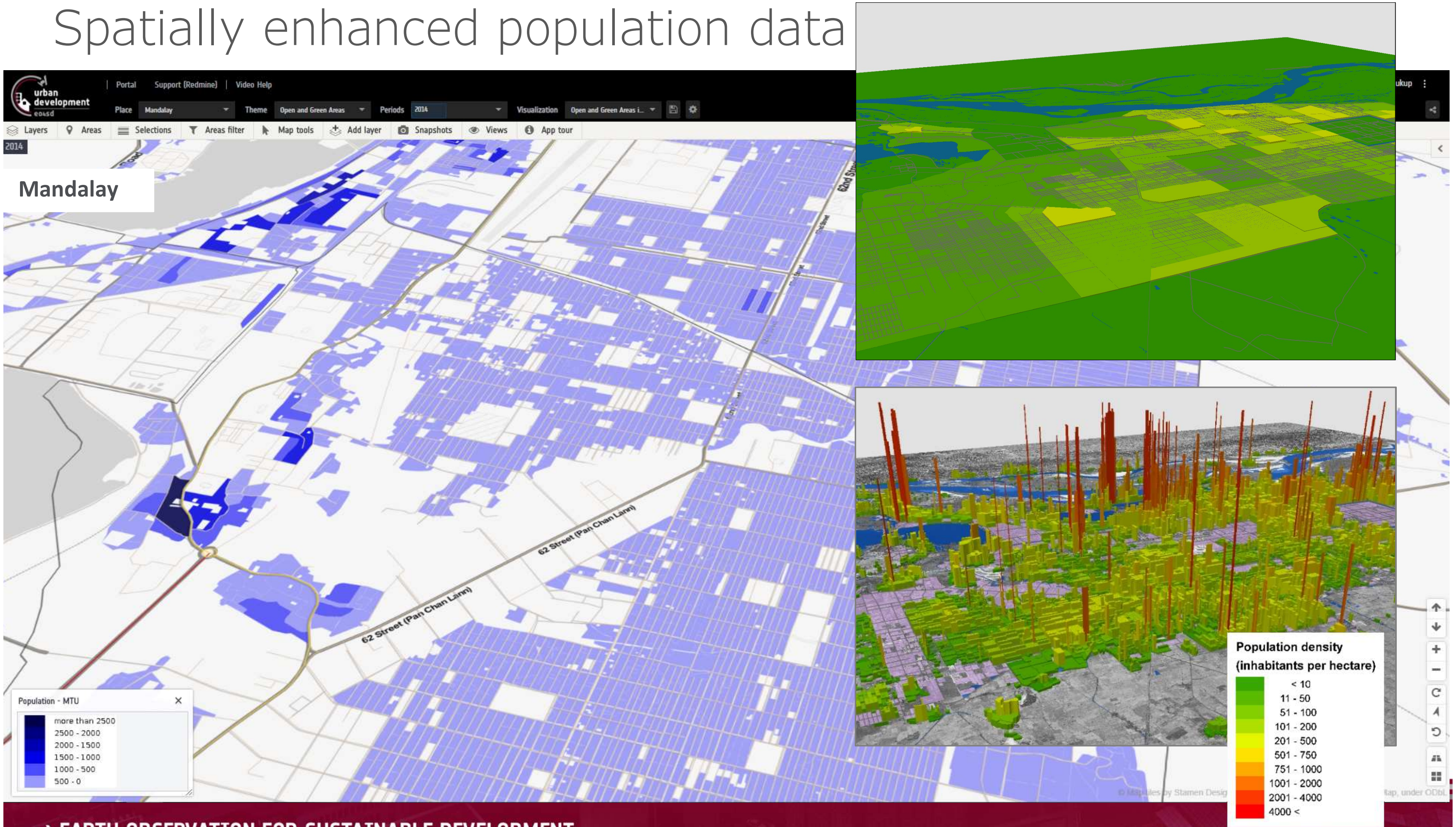
Operational Level Support
Population Distribution / Density

LULC, Census Data and VHR DSM for urban blocks



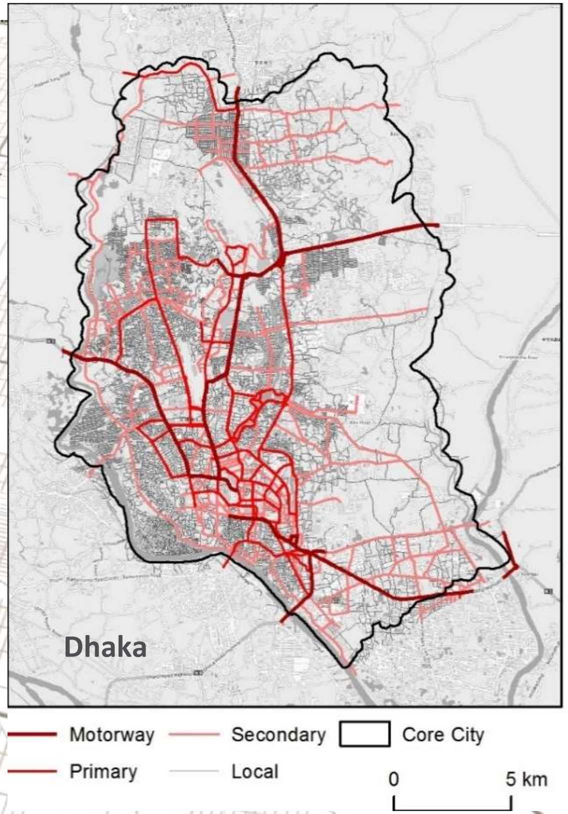
Operational Level Support
Population Distribution / Density

Spatially enhanced population data

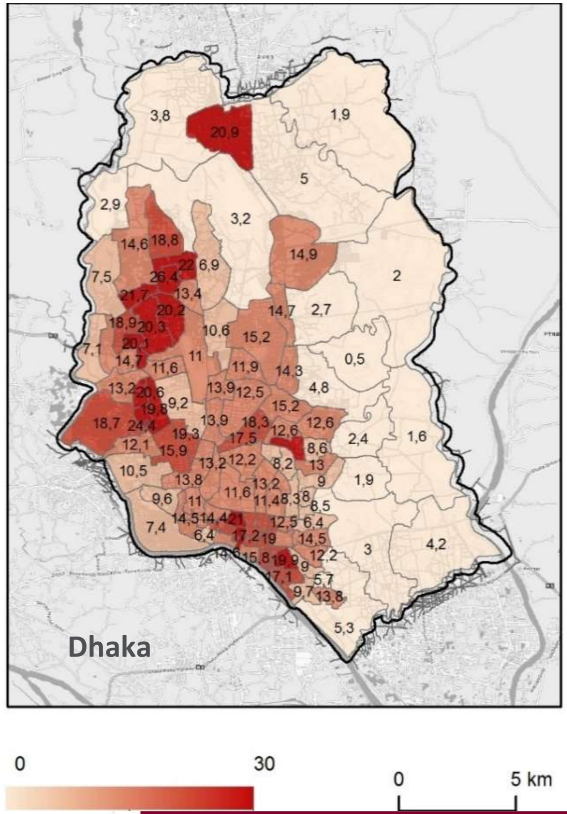


A street density (road surface / total area) gives a quick understanding about the typology of the City.

Transportation network map



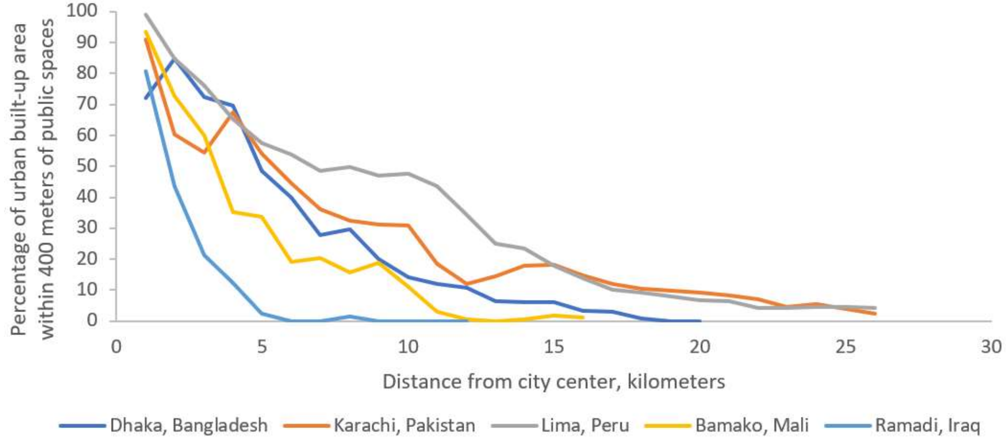
Network density



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

Inclusivity

It refers to a distance of 400 meters or less. The definition and locations of city centers are explained in each case study later this chapter; and the public spaces included in this analysis are parks, waterfronts, squares, and markets, excluding streets.



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

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.

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).

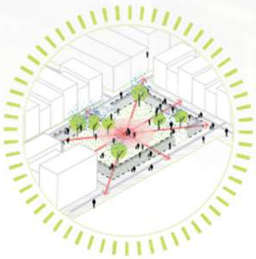
Identification, quantification and characterization of potential public urban spaces

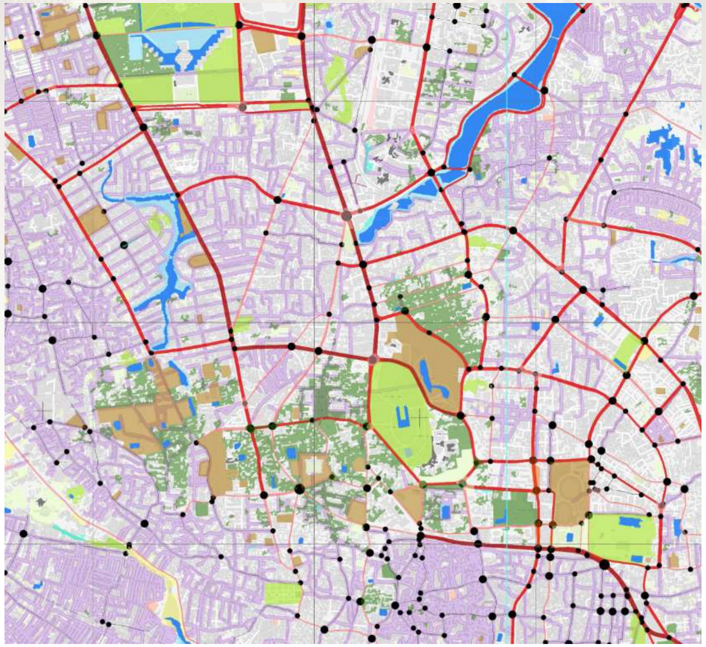
Coherent with SDG 11.7 implementation (UN-HABITAT)

Buildings

Streets

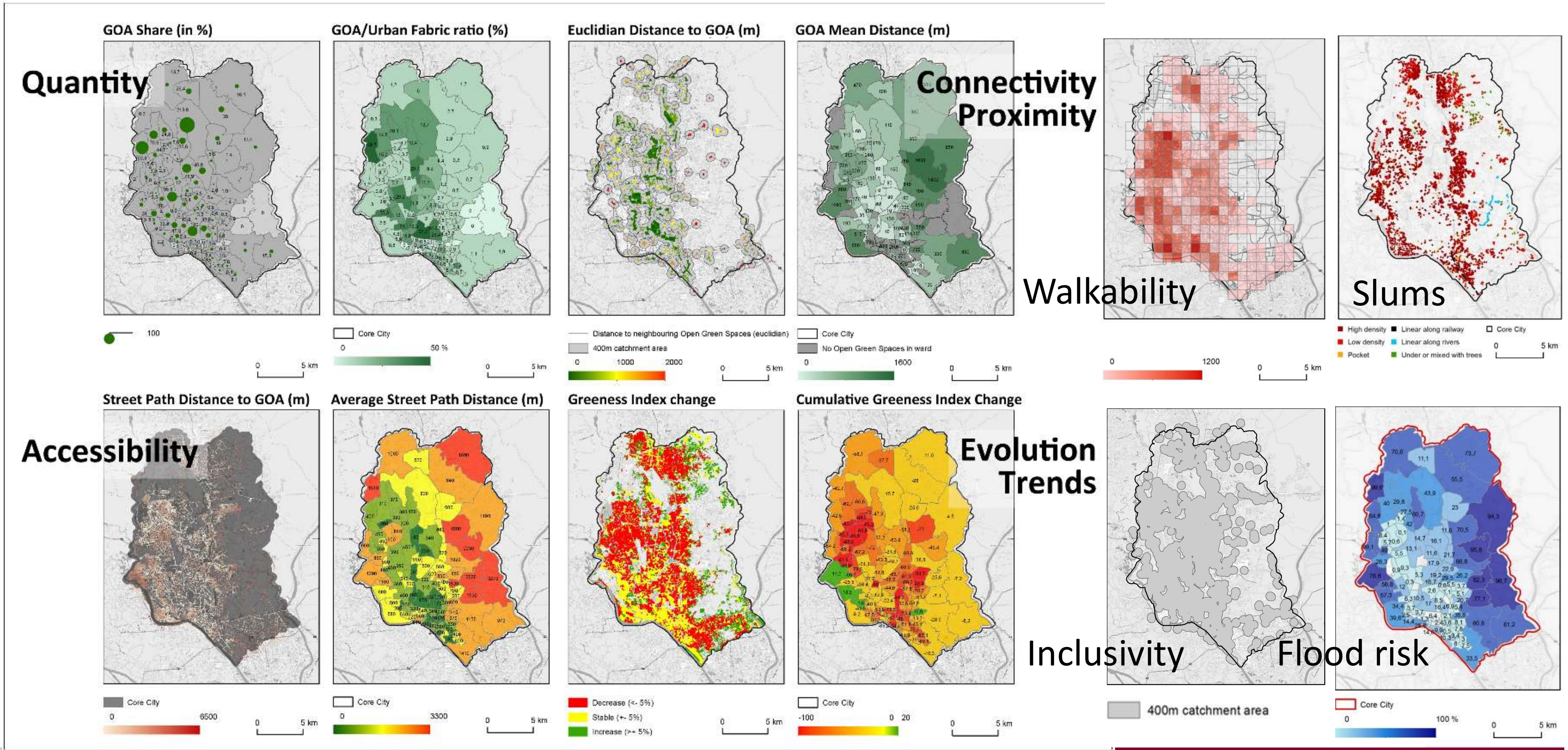
Open and Green Areas





Step II: City-wide Assessment
Testing Analytics

Spatial Analysis describing public space network



Operational Level Support
Public Spaces

EO supporting a full planning cycle

D. KHILGAON-BASHABO

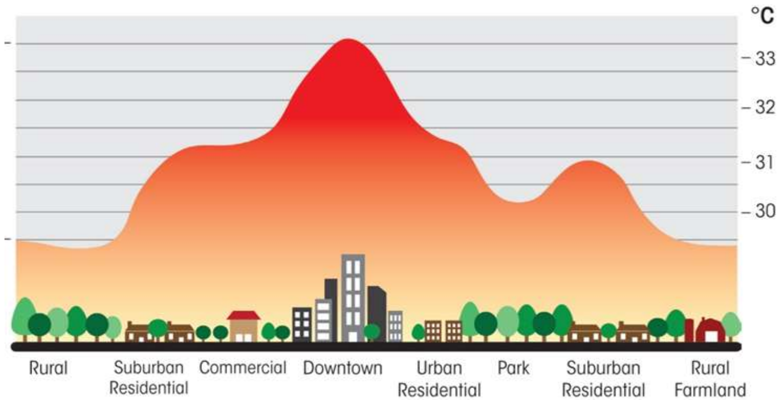
NR	NAME	TYPE	OWNER	DIMENSION	COST (USD)	YEAR
D01	Streets around Shajahanpur Jheel	STREET	DSCC	978 m long	1,526,700	1-2
D02	Shajahanpur Jheel	O. SPACE	WASA	21,290 sqm	1,472,400	1-3
D03	Fields around Shajahanpur Jheel	O. SPACE	PWD, WASA	9,070 sqm	1,465,100	1-3
D04	Atish Deepankar Crossings	STREET	RAIL, DSCC	5,000 sqm	276,600	1-3
D05	Amtola Mosjider Goli Road	STREET	DSCC	380 m long	135,500	1-2
D06	Shahid Baki Road	STREET	DSCC	1.8 km long	2,872,500	3
D07	Khilgaon Taltola Community Center	BUILDING	DSCC	2,820 sqm	1,192,300	1
D08	Road in front of Khilgaon Taltola Cementery	STREET	PWD	225 m long	730,900	2
D09	Road in Bhuyan Math area	STREET	DSCC	945 m long	1,190,200	1
D10	DSCC office and Community Center	BUILDING	DSCC	1160 sqm	2,762,500	2
D11	Bhuyan Math Playground	O. SPACE	PWD	5,810 sqm	1,313,100	2
D12	Goran Road	STREET	DSCC	304m long	53,600	1-2
D13	Shantipur Road	STREET	DSCC	673 m long	247,200	1
D14	Green spaces around Bashabo Community Center	BUILDING	DSCC	2,770 sqm	346,200	1
D15	Atish Deepankar Sidewalks	STREET	DSCC	520 m long	210,000	1
D16	Bashabo Balur Math and Road	O. SPACE	DSCC	2,280 sqm	1,626,000	1
D17	Roads around Bashabo Balur Math	STREET	DSCC	750 m long	394,500	1
D18	Shabujbag Thana Muktijoddha Community Center	BUILDING	DSCC	200 sqm	345,000	1
D19	Shabujbag middle Bashabo Children park	O. SPACE	DSCC	-	-	-
D20	Street Around Bashabo Thana area	STREET	DSCC	-	-	-
D21	Atish Deepankar Community Center	BUILDING	DSCC	1,030 sqm	2,213,600	1

Strategical / Operational Level Support
Heat Intensity / Heat Stress

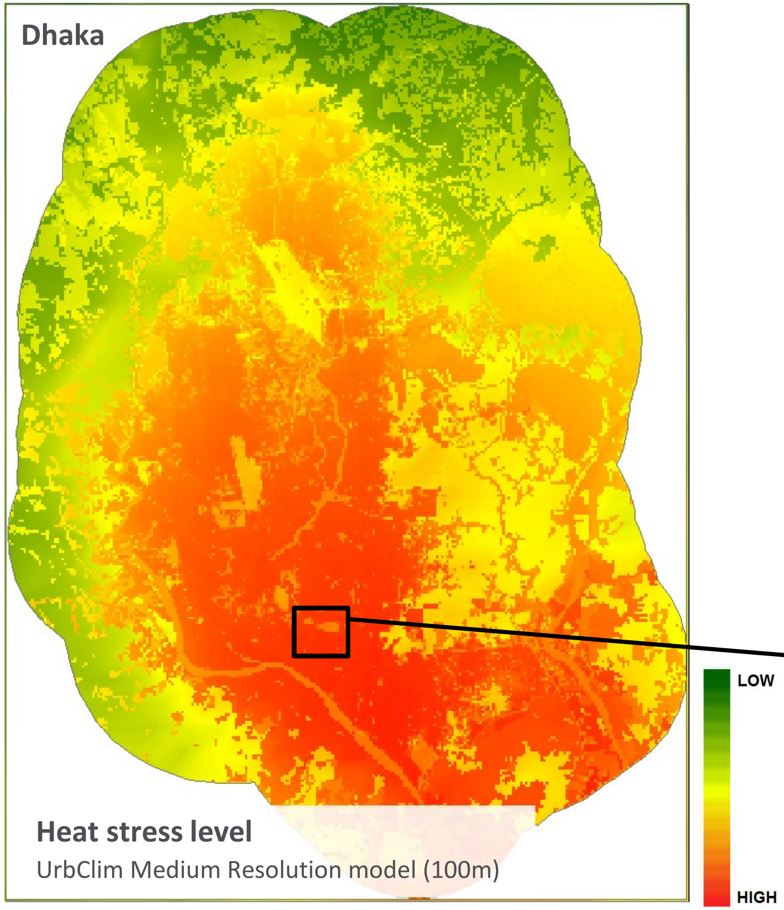
City structure (LU/LC) links to a climate conditions in the city (distribution of heat-stress)

- 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



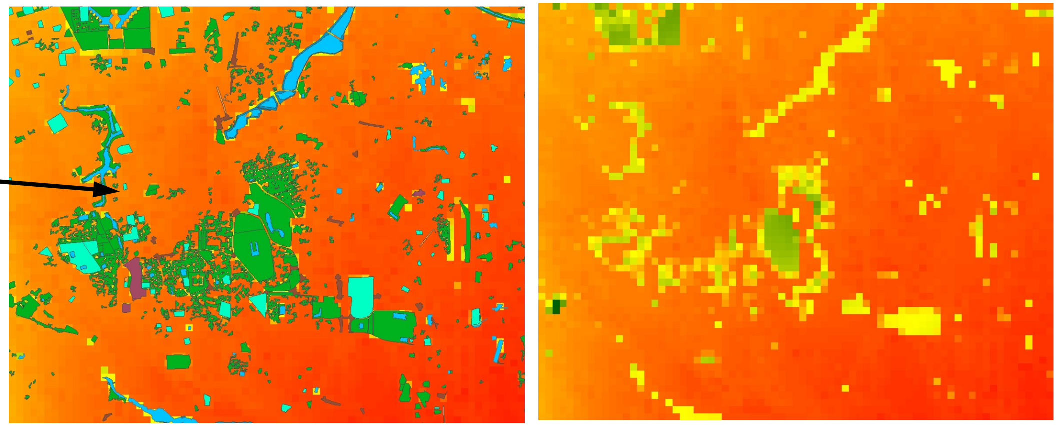
City-level planning, hot-spots, long-term development strategies



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

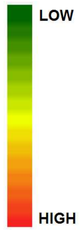
Cooling effect of Green Areas



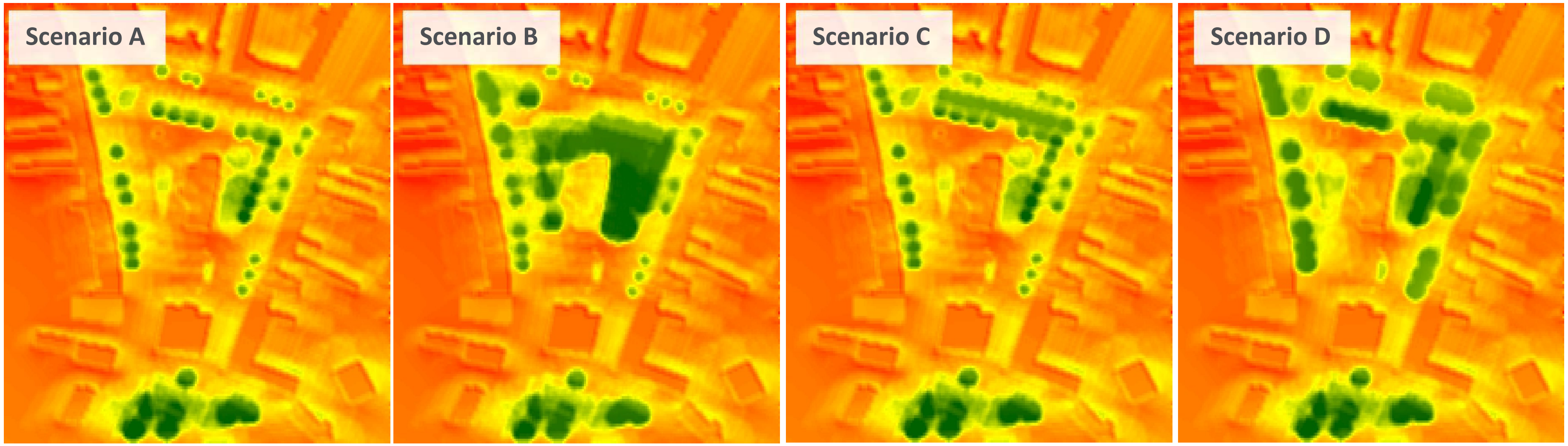
Operational Level Support
Heat Stress

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

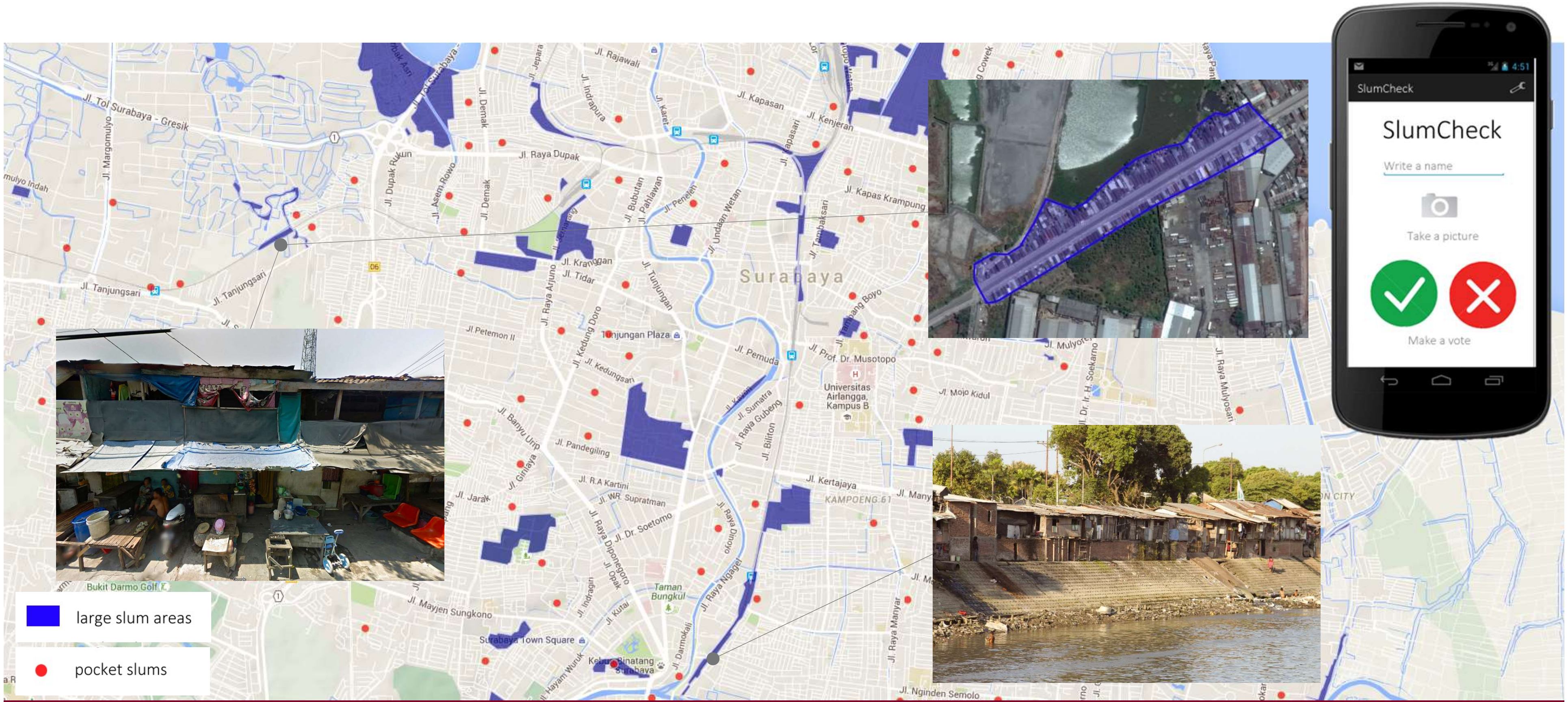


Heat stress level



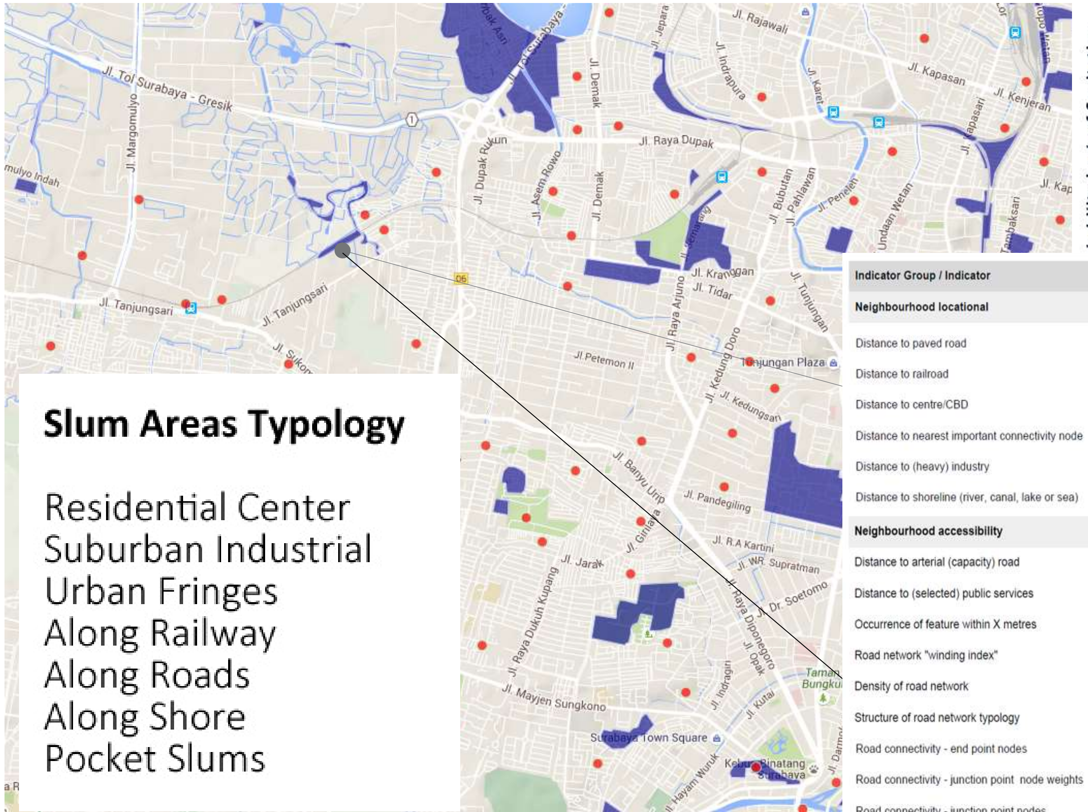
Heat Stress Index (WBGT Index), is a wide spread used indicator (ISO 7243:2017) for assessment the impact of urban climate environment on the people in the city.

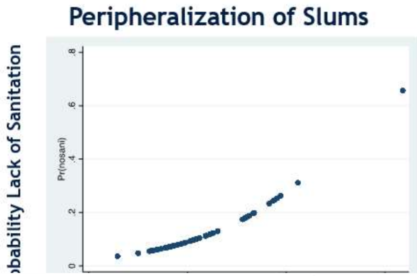
Informal settlements inventory - on-site verification (e.g. crowd source supported)



Slum area characterization - slum areas typology

Slum service deprivation modelling

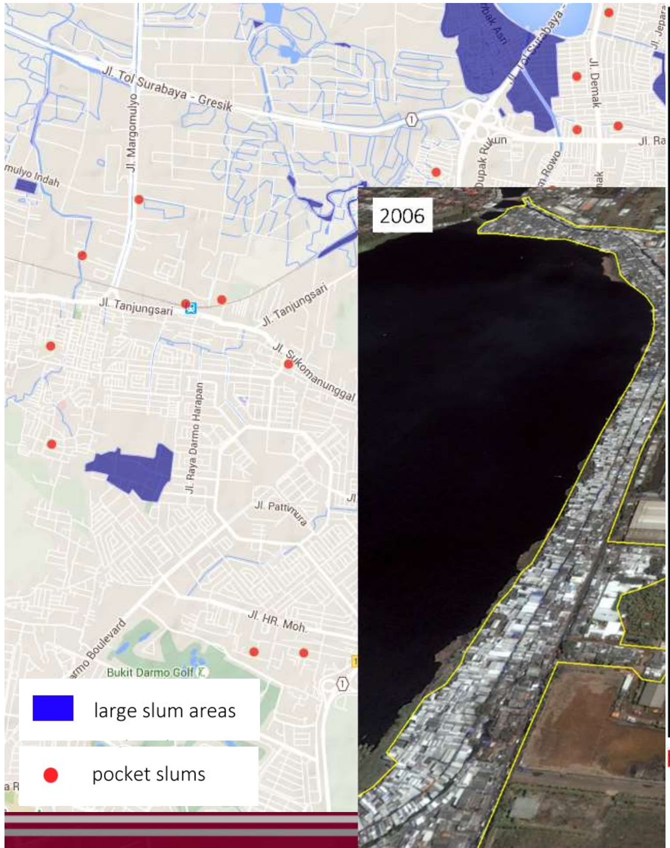


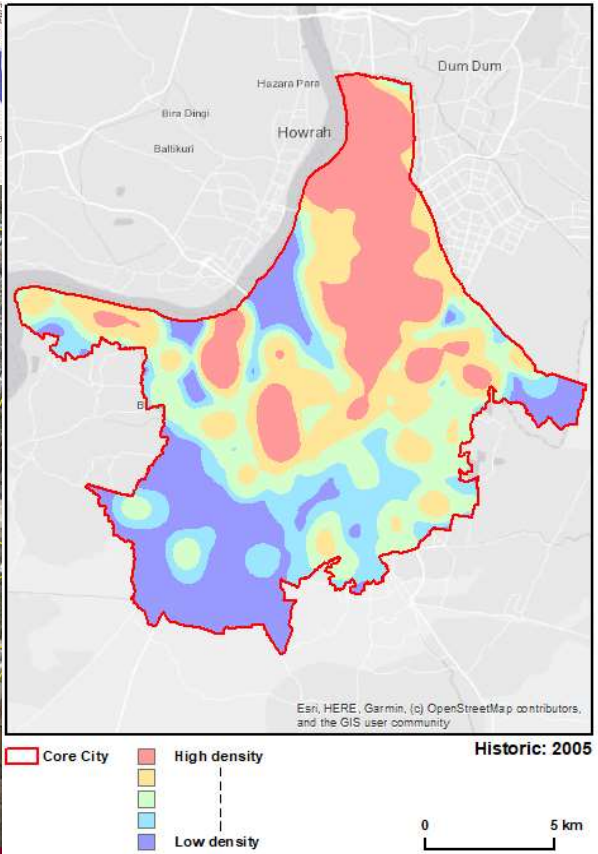


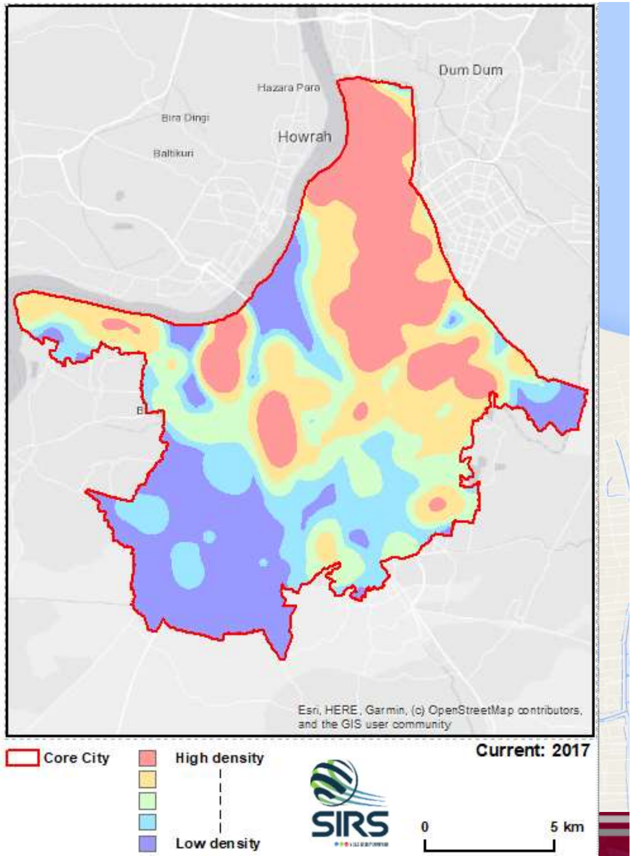
Indicator Group / Indicator	Indicator type	Input Data
Neighbourhood locational		
Distance to paved road	Quantitative	OSM, LULC
Distance to railroad	Quantitative	OSM, LULC
Distance to centre/CBD	Quantitative	LULC
Distance to nearest important connectivity node	Quantitative	OSM, LULC
Distance to (heavy) industry	Quantitative	LULC
Distance to shoreline (river, canal, lake or sea)	Quantitative	LULC
Neighbourhood accessibility		
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
Neighbourhood shape morphological characteristics		
Area	Quantitative	GIS
Perimeter	Quantitative	GIS
Shape compactness	Quantitative	GIS
Neighbourhood LULC proportional characteristics		
LULC structure in surroundings	Quantitative	GIS
Neighbourhood internal structure		
Built-up homogeneity	Quantitative	OBIA
Built-up density	Quantitative	OBIA
Open spaces density	Quantitative	OBIA
Greenness density	Quantitative	OBIA
Neighbourhood dwelling characteristics		
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

Slum development monitoring - change detection

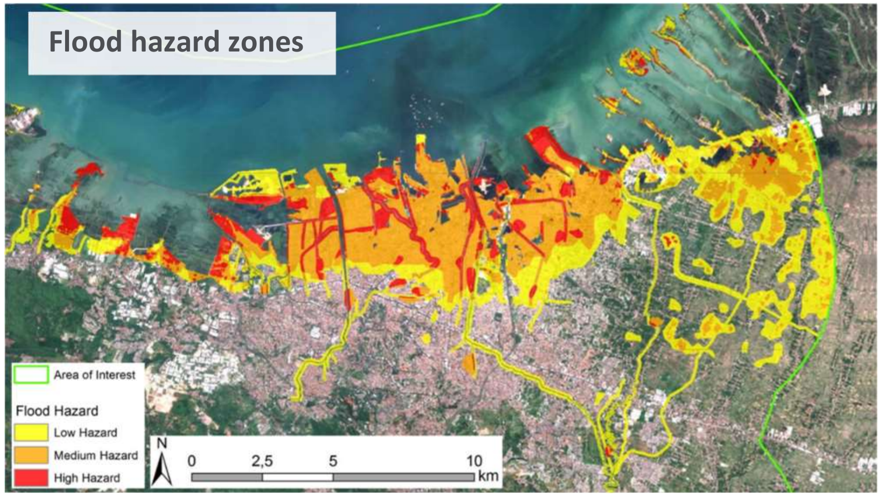


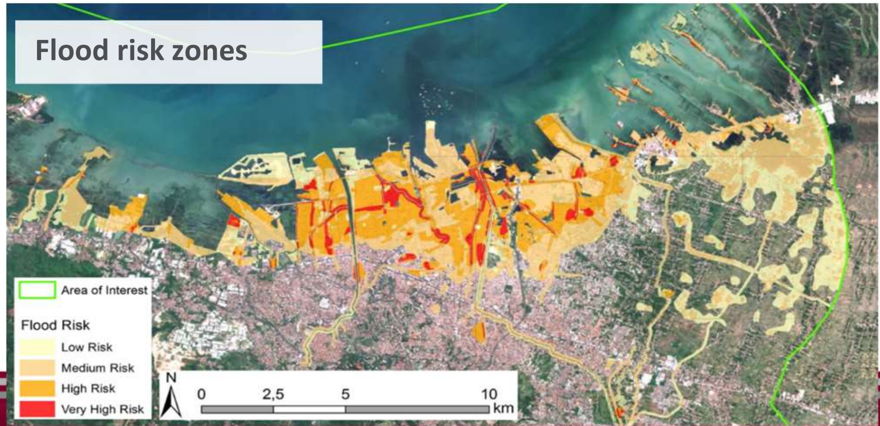


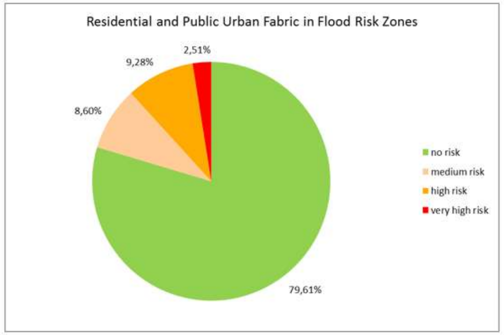


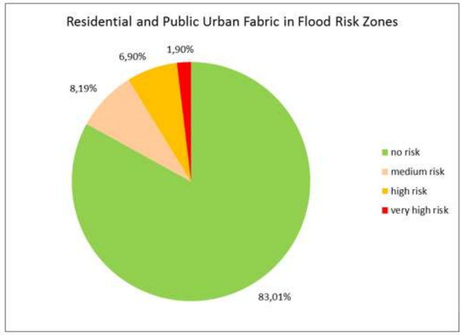
Risk Assessment

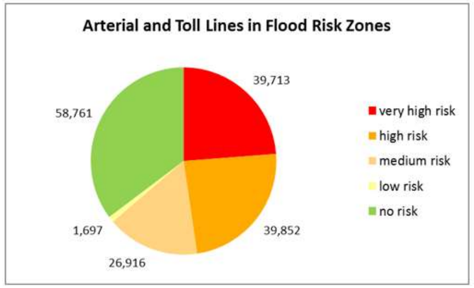
Multiple hazards which put in danger the City assets, some of them boosted by Climate Change (flood, subsidence, earthquake, landslides)

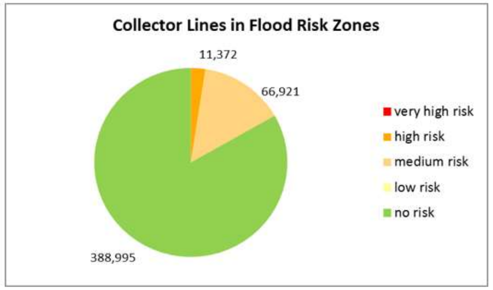








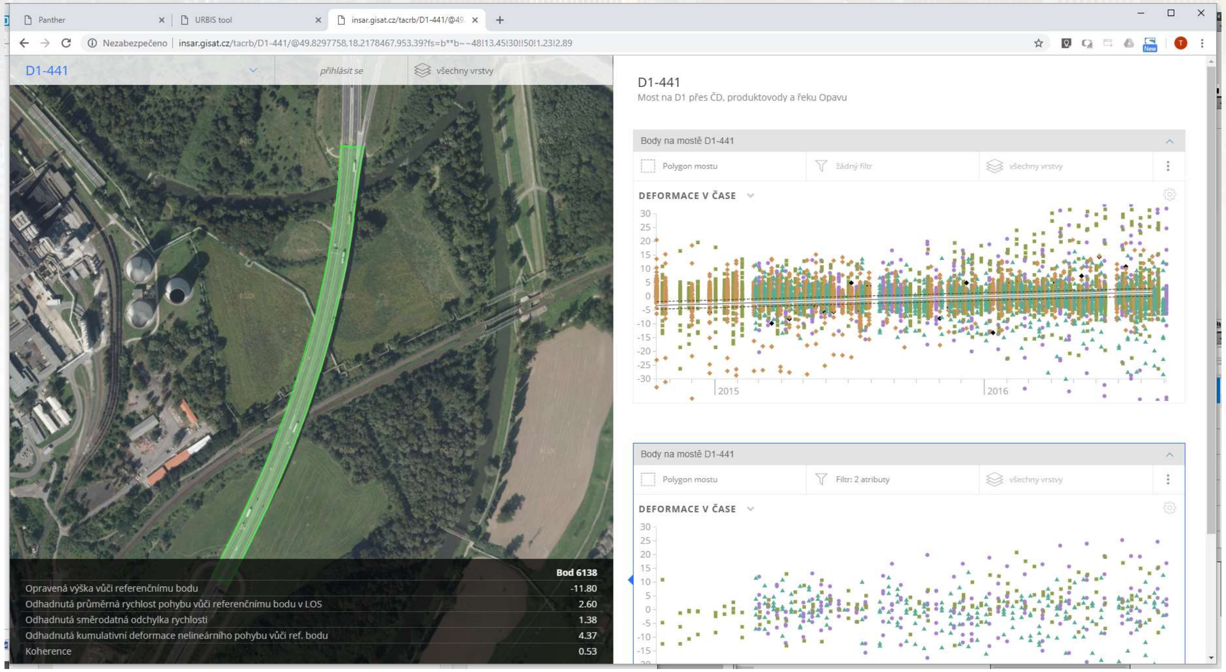


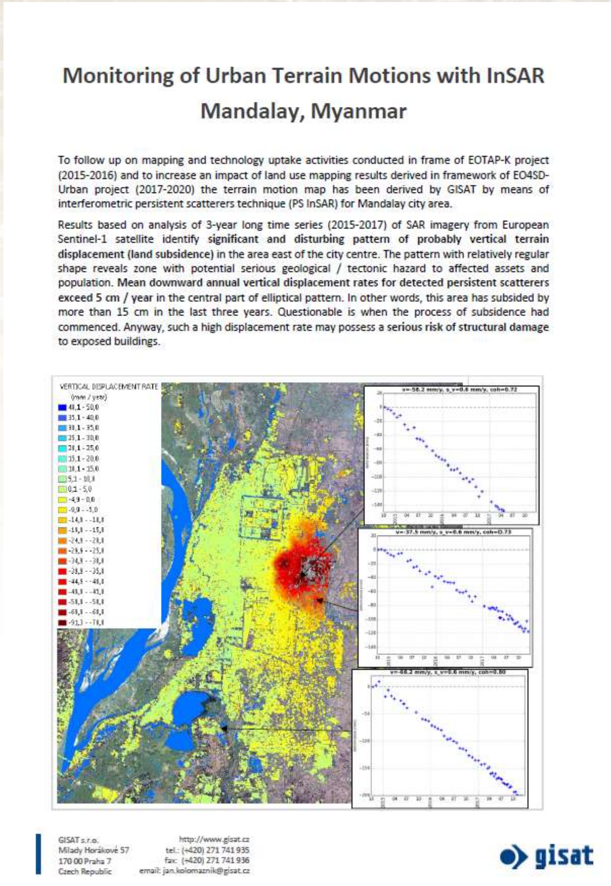


Example from Semarang for flood risk.
Hazard and risk zone and base statistics of the City assets affected.

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 EO4SD-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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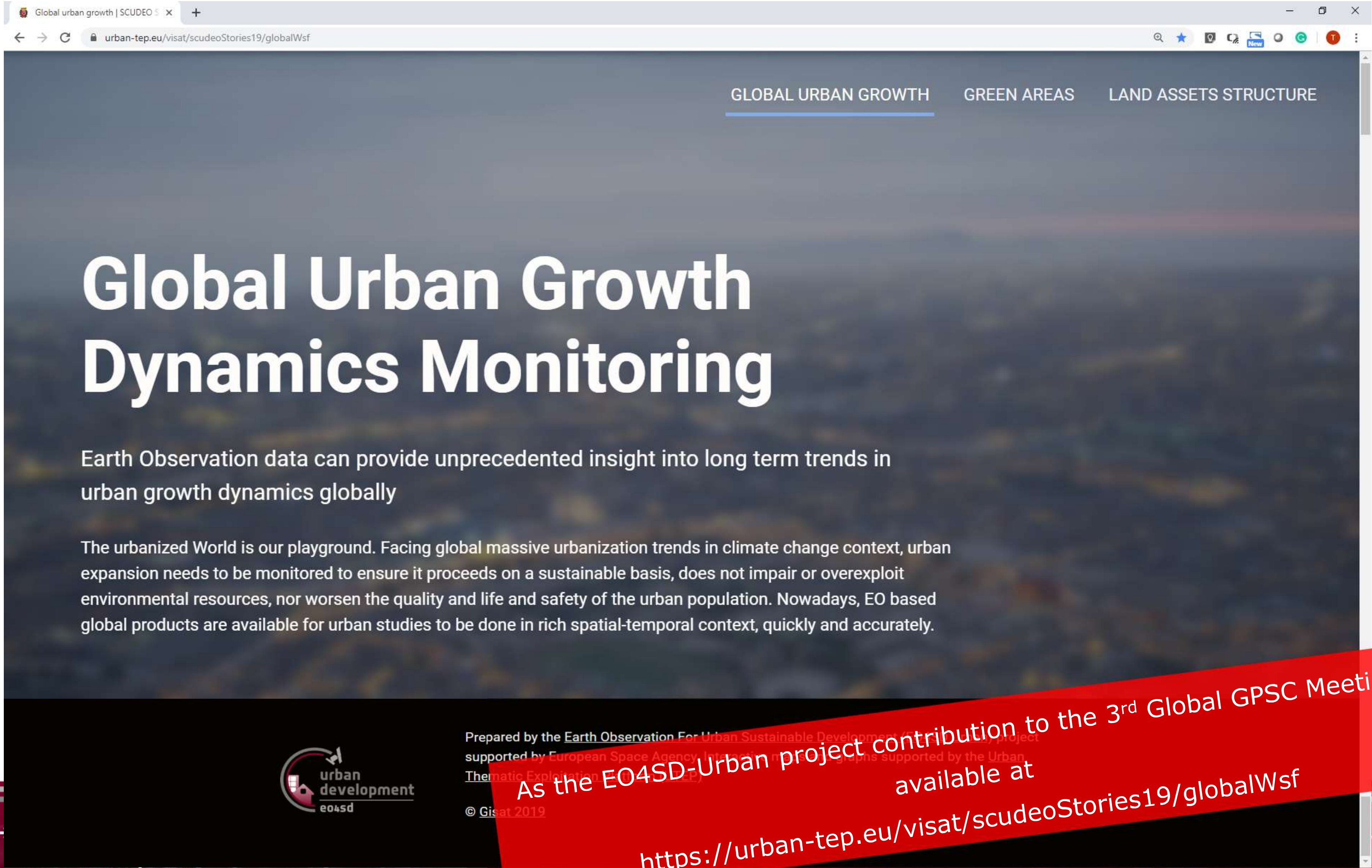
Conclusions

- We can do so much using EO data comparing with just a few years ago due to recent technical advances and it is still just a beginning… the sky is the limit
- Finally, EO is important, but only one element and the future is clearly in integration of data from different sources with spatial component as a key for integration
- So much information from different sources starts already now to be difficult to digest, but advances in big data analytics and visualization will help to better pass important messages, supporting storytelling to move people to actions.

Announcement

Online Storylines



As the EO4SD-Urban project contribution to the 3rd Global GPSC Meeting
available at
https://urban-tep.eu/visat/scudeoStories19/globalWsf

Online Storylines

esa

Land assets structure | SCUDEO

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

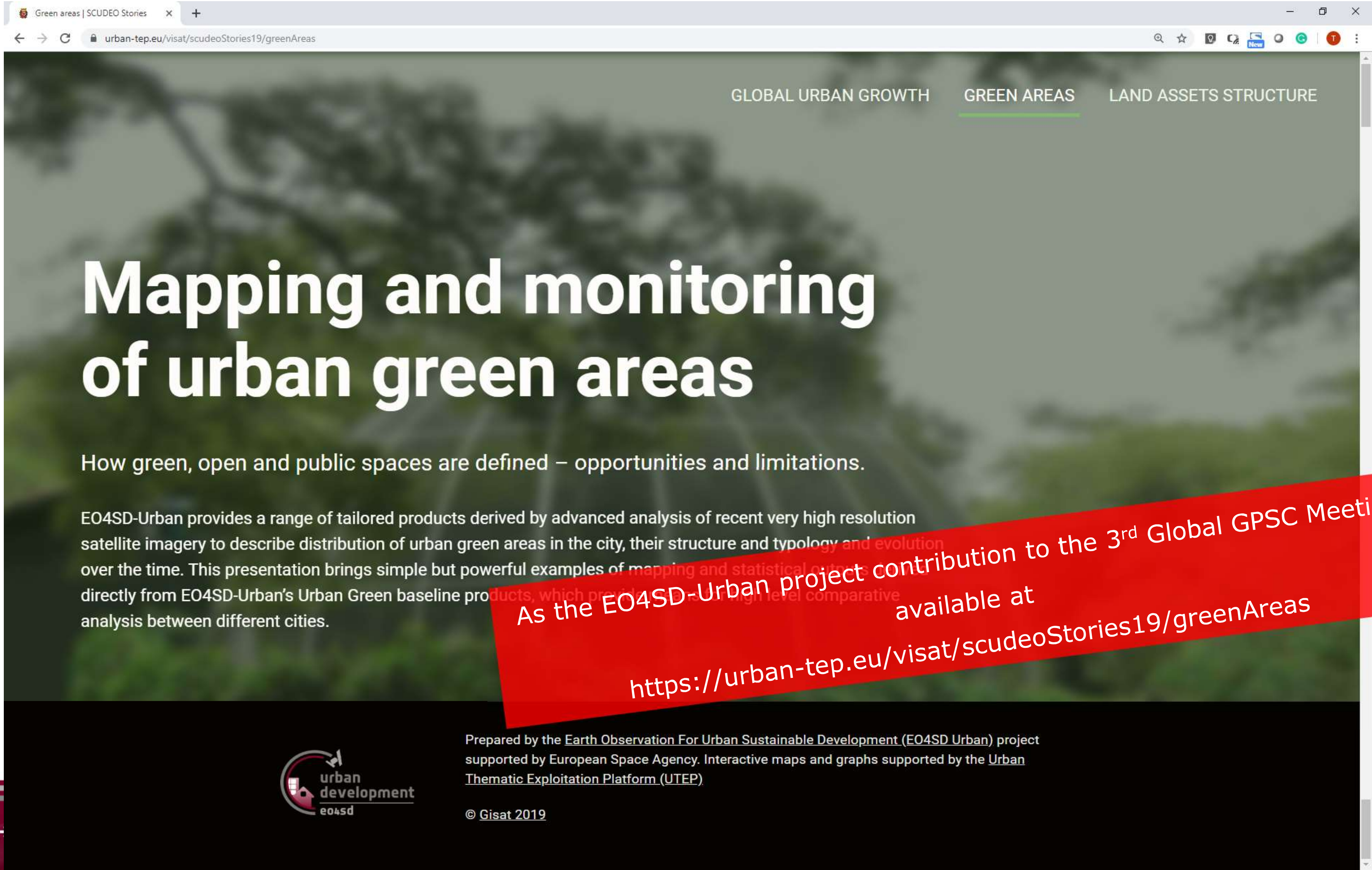
Land is a non-renewable resource and its quantity and quality play a vital role in the development of a city. Land ... structure and spatial-temporal patterns to a large extent influence city livability and ... as well as determine physical constraints, opportunities and potential for further development.

As the EO4SD-Urban project contribution to the 3rd Global GPSC Meeting available at https://urban-tep.eu/visat/scudeoStories19/landAssetsStructure

urban development eo4sd

Prepared by the Earth Observation For Urban Sustainable Development (EO4SD Urban) project supported by European Space Agency. Interactive maps and graphs supported by the Urban Thematic Exploitation Platform (UTEP)

Online Storylines



As the EO4SD-Urban project contribution to the 3rd Global GPSC Meeting available at

https://urban-tep.eu/visat/scudeoStories19/greenAreas

Thank you for your attention!

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