→ 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

Tomas Soukup, GISAT
Amelie Broszeit, GAF AG

urban development eo4sd

GAFAG SIRS gisat DLR egis JOANNEUM RESEARCH NEO GISBOX

Agenda and Speaker

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

Speaker

Tomas Soukup

Senior Remote Sensing
& GIS Consultant
GISAT, Czech Republic

Outline of the Presentation

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

Context

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

Urban Development Agenda

- 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

European Contribution

SENTINELS FREE AND OPEN ACCESS

European Contribution

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
A 3 Apr. 2014	A 23 Jun. 2015	A 16 Feb. 2016	A 2022	A 13 Oct. 2017	A 2021	A 2020
B 25 Apr. 2016	B 6 Mar. 2017	B 25 Apr. 2018	B 2027		B 2027	B 2025
C 2022/23	C 2022/23	C 2023			C > 2027	
D > 2022/23	D > 2022/23	D > 2023				

→ EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT
Urban development

European Contribution

COPERNICUS IN SUPPORT OF THE UN SUSTAINABLE DEVELOPMENT GOALS

- vital European EO Service Providers Segment

=> European capacity for support

urban development
eo4sd

European Commission
Copernicus

Urban Planning and EO

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

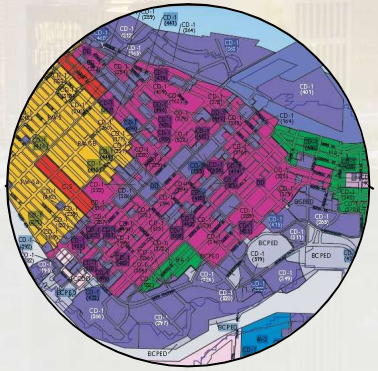
- highly complex process based on responsible balancing of advantages and disadvantages from a holistic perspective, taking in account multiple public or private interests.
- the most important condition for the balancing of pro's and con's and a development of strategic orientation for future planning 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.

Urban Planning and EO

Knowledge needs are complex

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

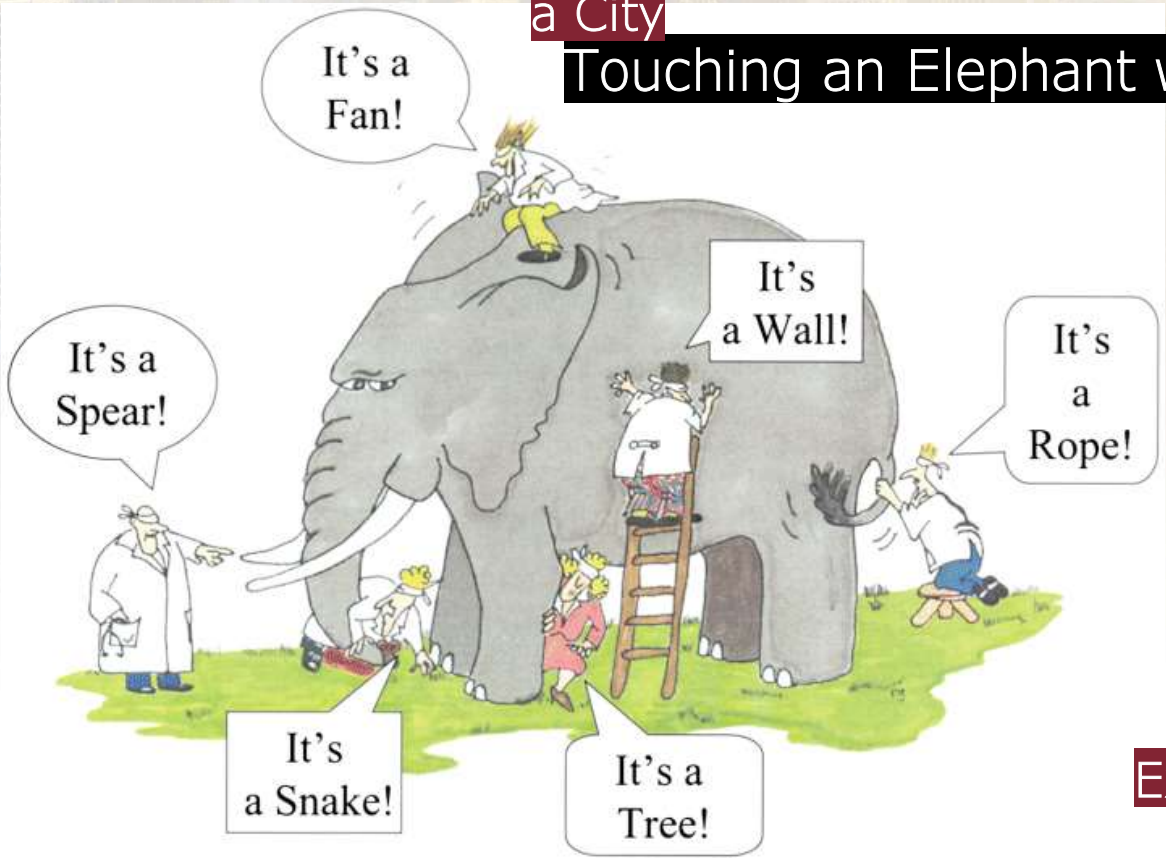
PUBLIC LIFE/PEOPLE
Culture
Health
Safety
Recreation
Livelihoods
Mobility
Inclusion

Urban Planning and EO

Reality is often simple

a City

Touching an Elephant with Closing Eyes



Lack of Data

Lack of Resources

Luck of Time

Existing Data in Silos

Urban Planning and EO

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	Potential for EO support
✓	✓	✗	Middle/high-income cities	
✓	✗	✗	Most of WB Client Cities	Extreme potential for EO support
✗	✗	✗	FCV Cities	

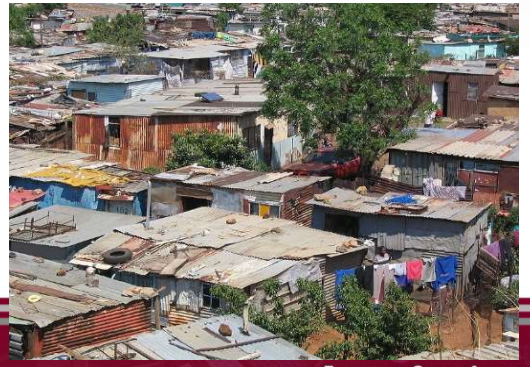
EO4SD Urban Service Offer

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)



EO4SD Urban Service Offer

EO Potential for Support for Urban Planning

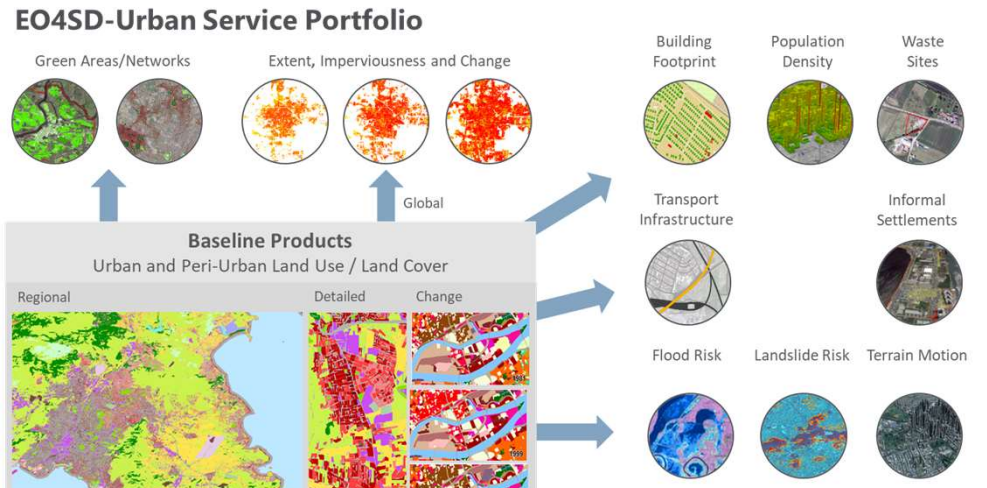
- Public spaces - urban green and open areas design and planning

- 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

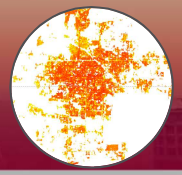


More information available at www.eo4sd-urban.info

Strategic level

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

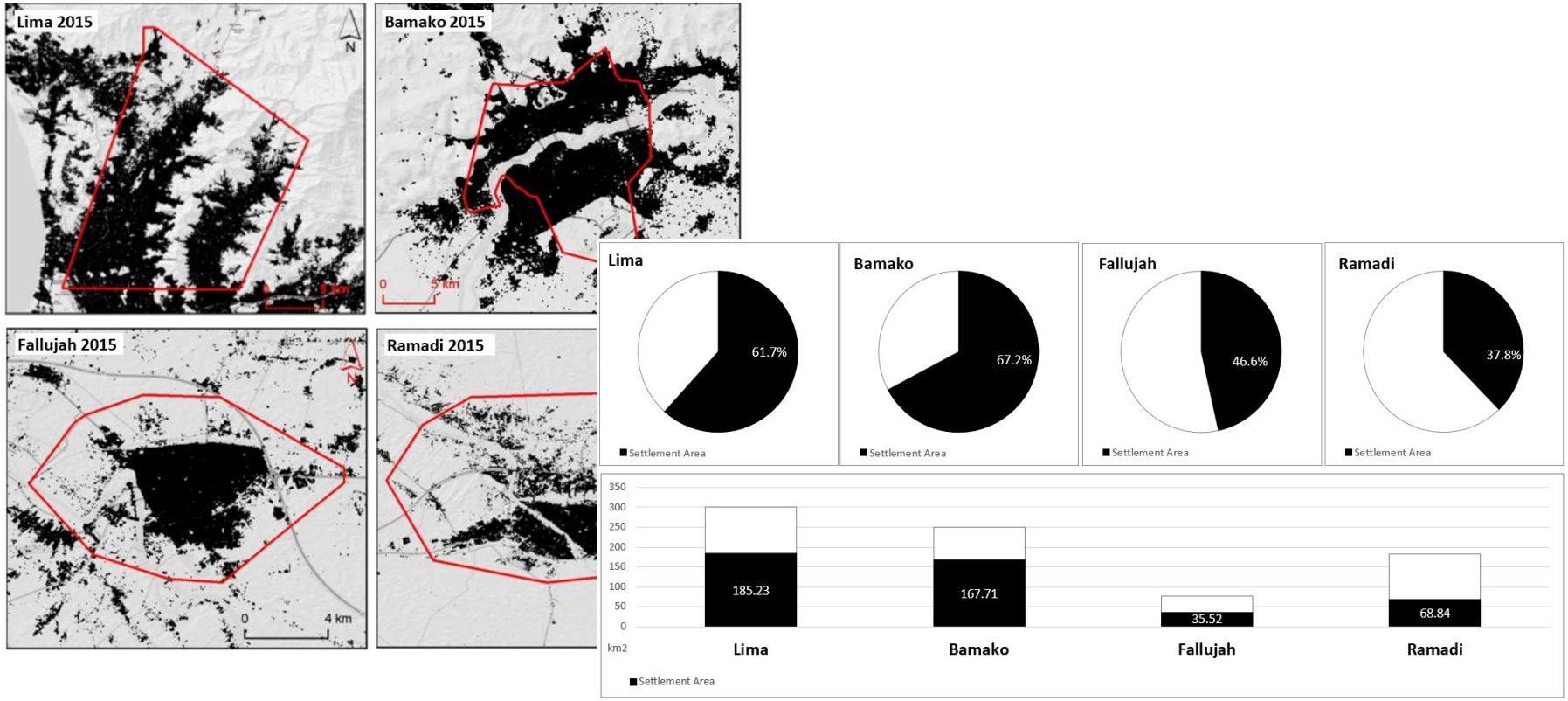
- Amount and distribution of built-up area
- Changes in space and time
- Main axes of development

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)

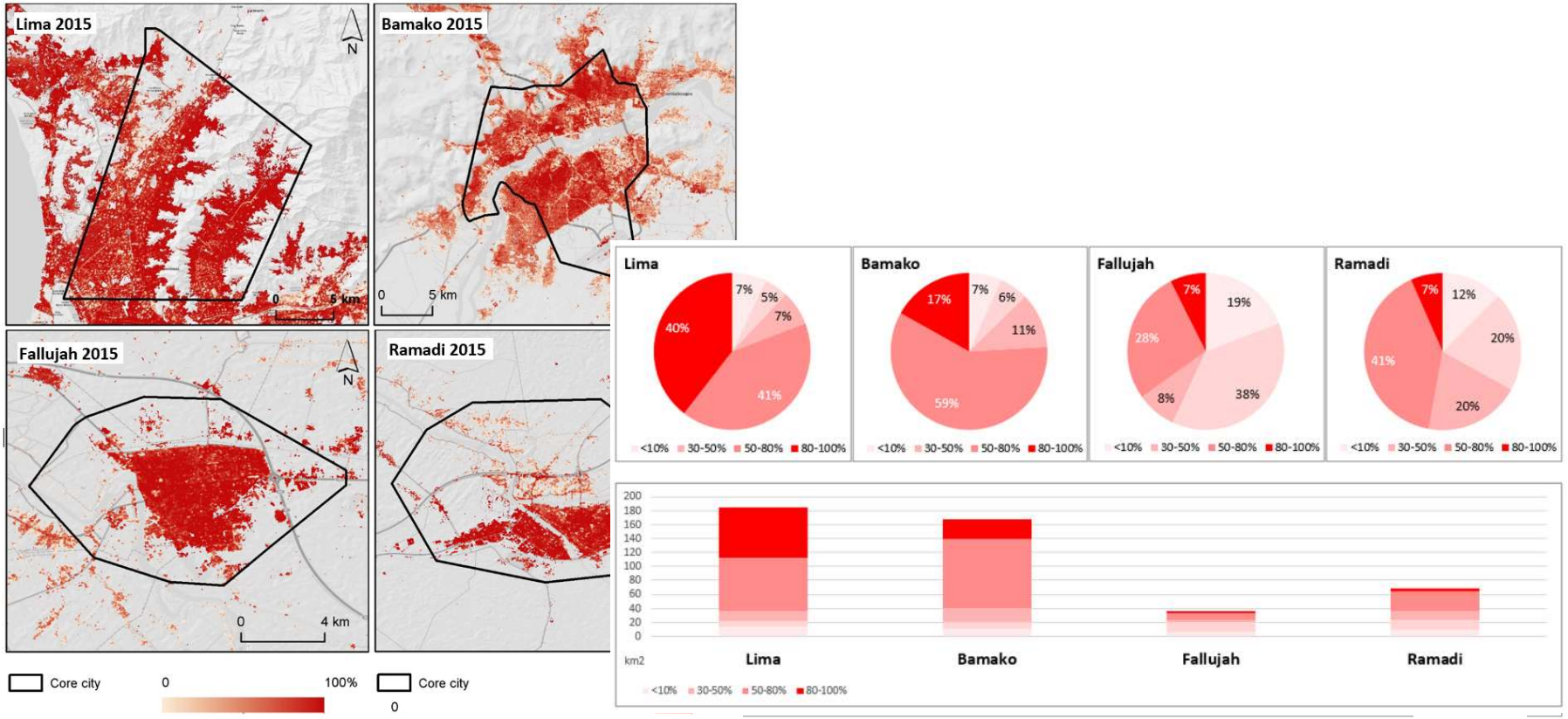
global ← → local

- Amount and distribution of built-up area

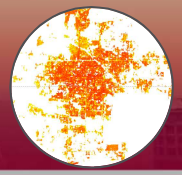


global — local

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

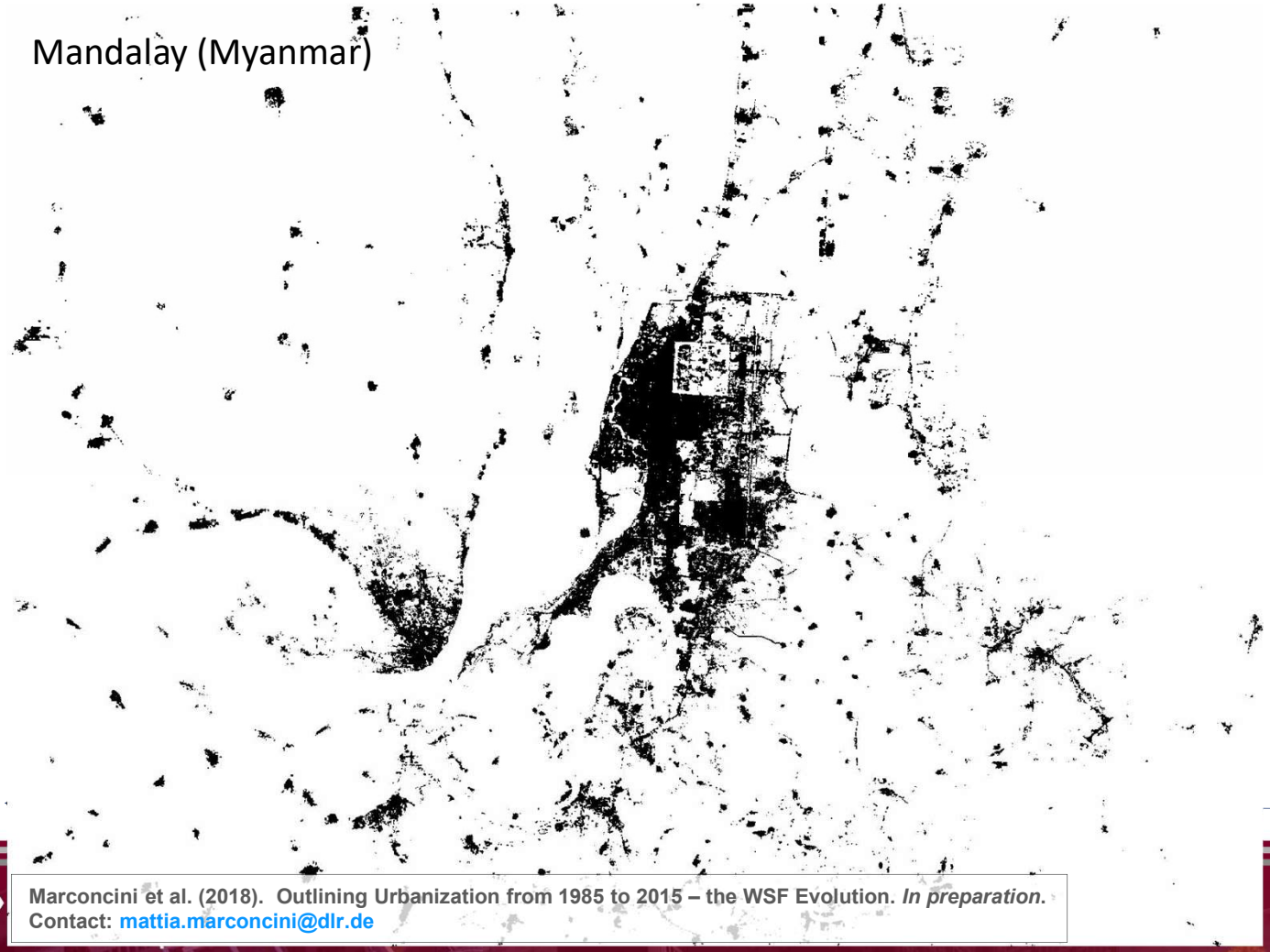


global — local



Urban Extent (and Change)
Global products

- Changes in space and time, axes of development



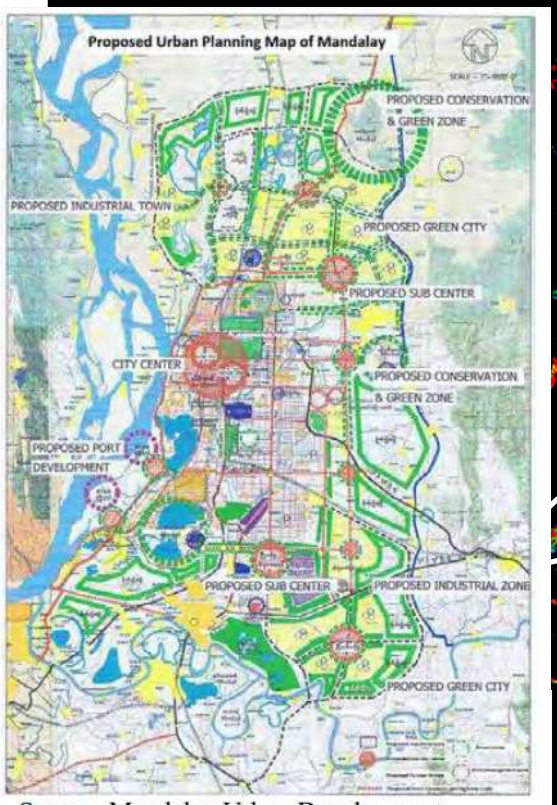
local →

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

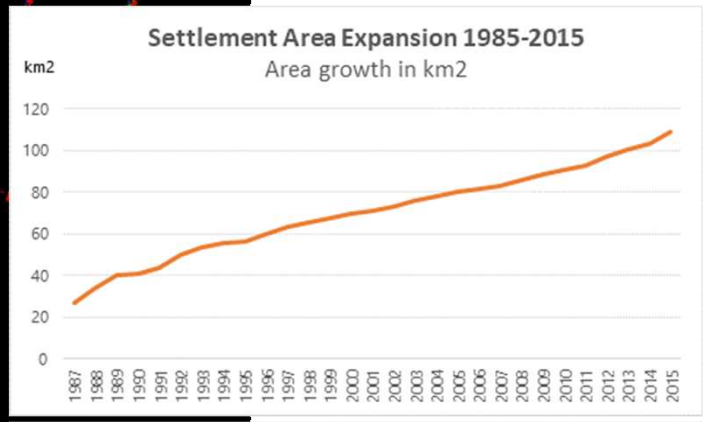
Urban Extent (and Change)
Global products

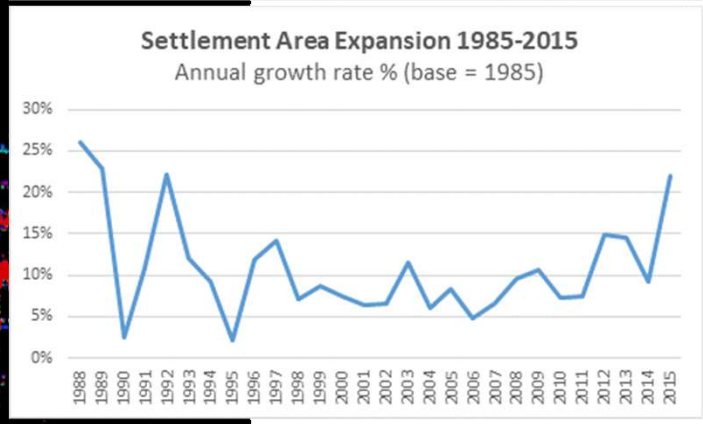
- Changes in space and time, axes of development

Mandalay (Myanmar)

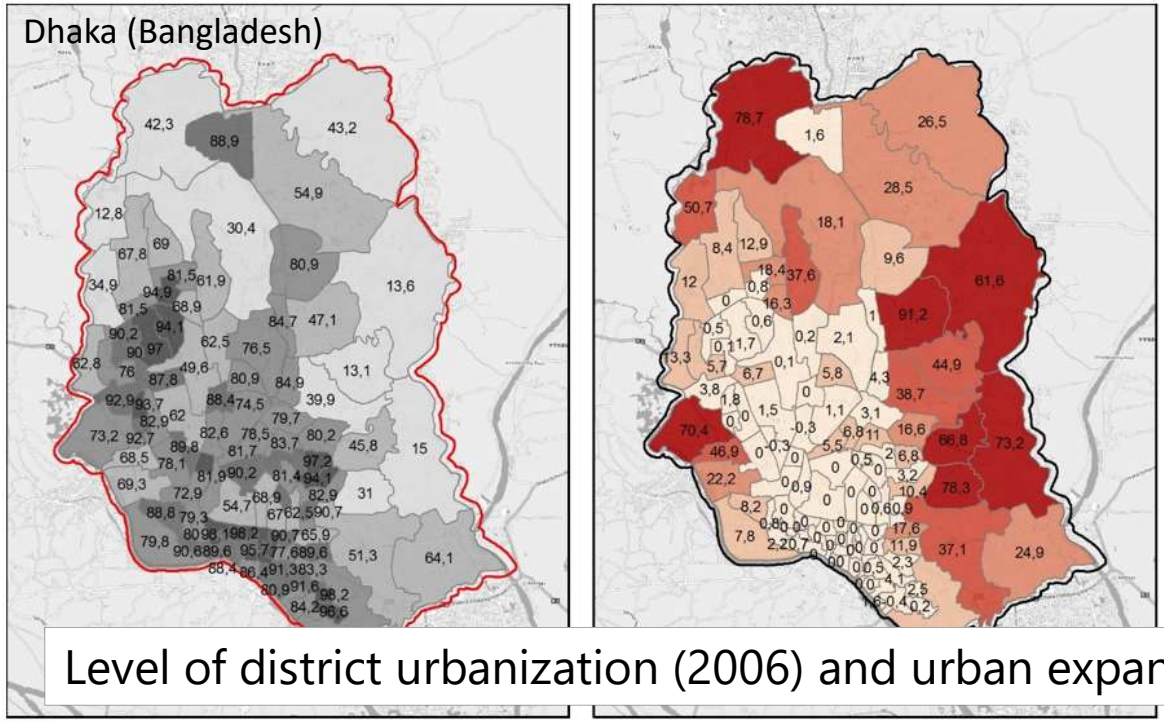


Source: Mandalay Urban Development Conceptual Plan, MOC





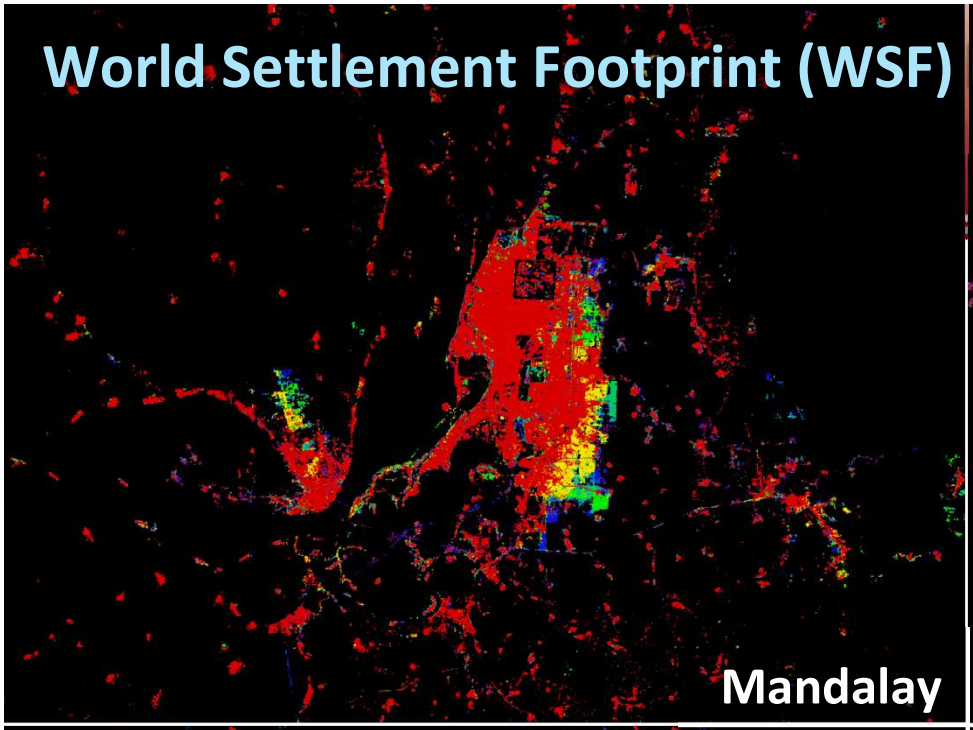
- Changes in space and time, axes of development

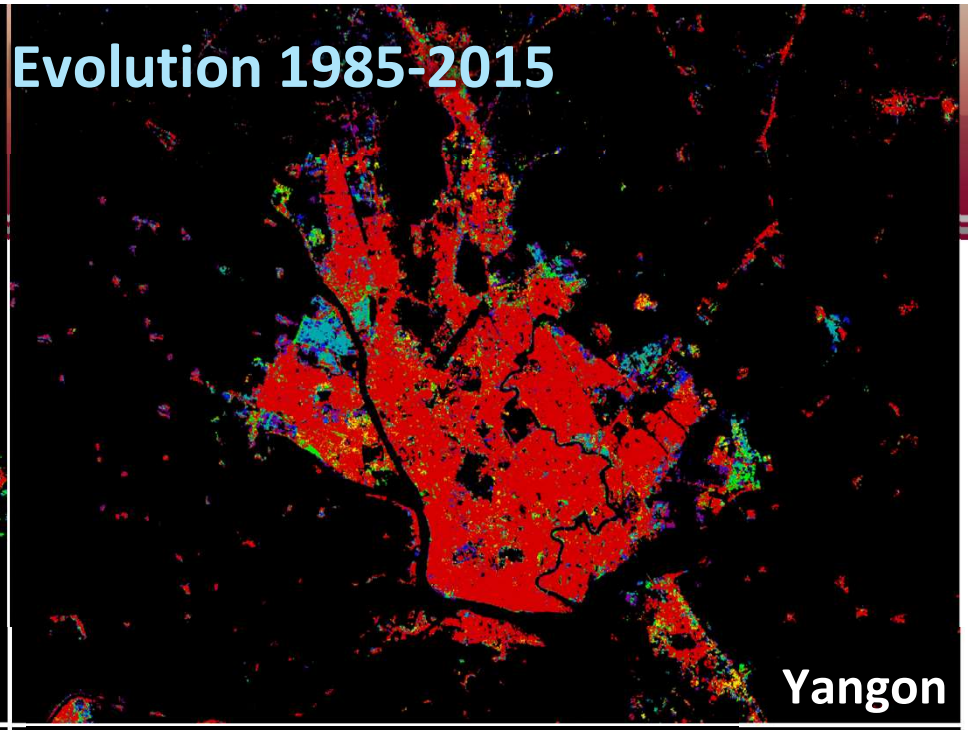


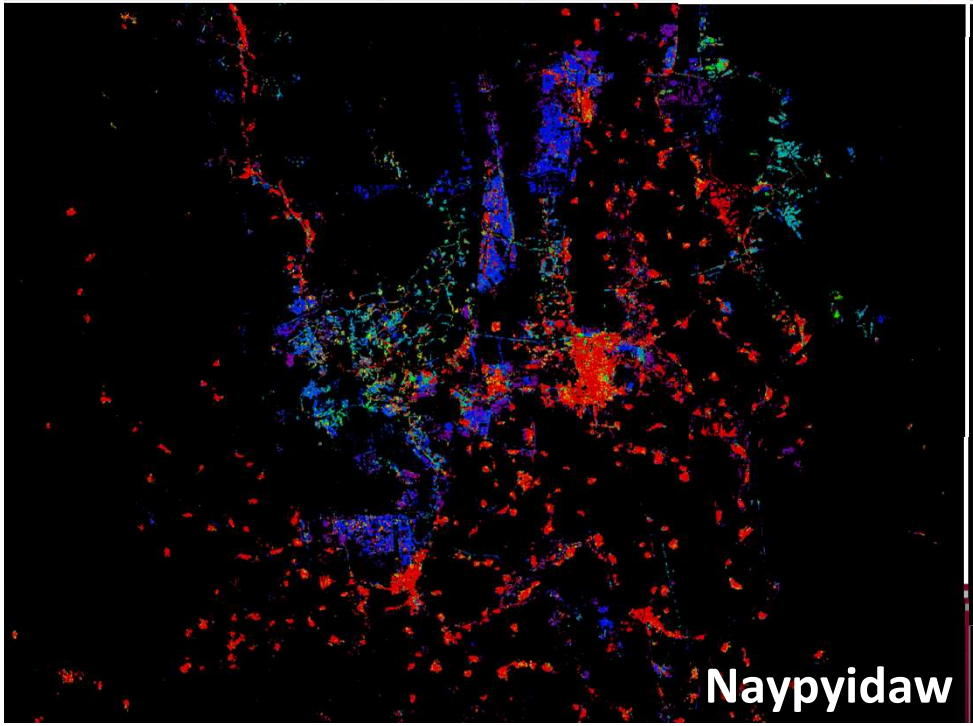
Level of district urbanization (2006) and urban expansion intensity 2006-2017

global ← → local

World Settlement Footprint (WSF) Evolution 1985-2015

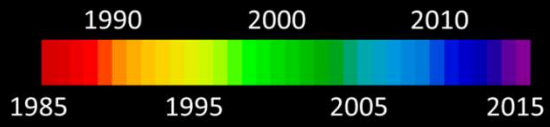






Legend

Reference years



DLR

Global WSF Evolution data freely available Q1/2020 via www.urban-tep.eu

Marconcini et al. (2018). Outlining Urbanization from 1985 to 2015 – the WSF Evolution. *In preparation.*
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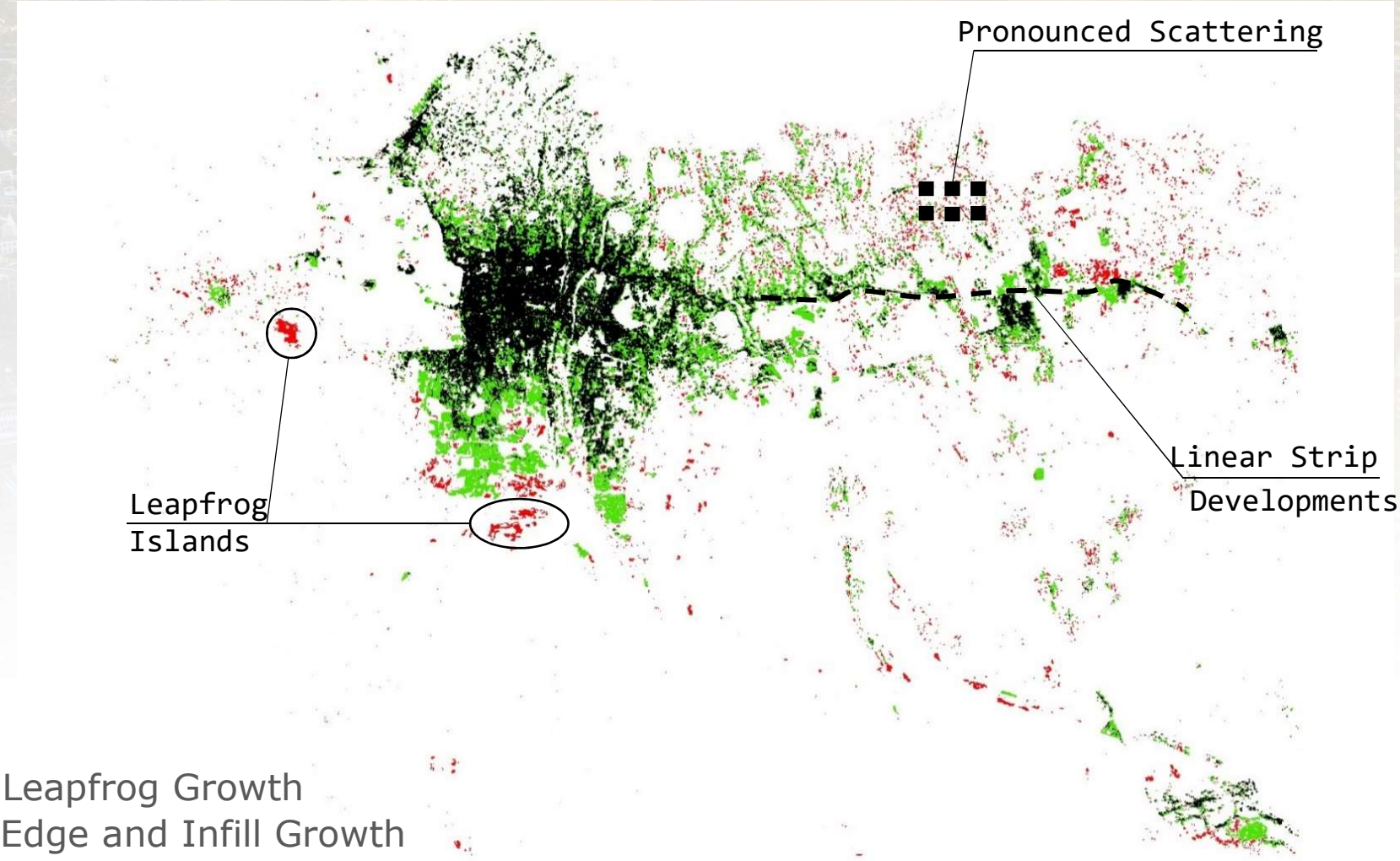
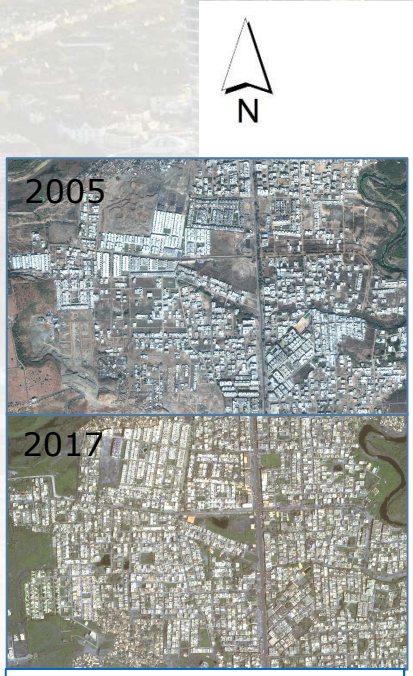
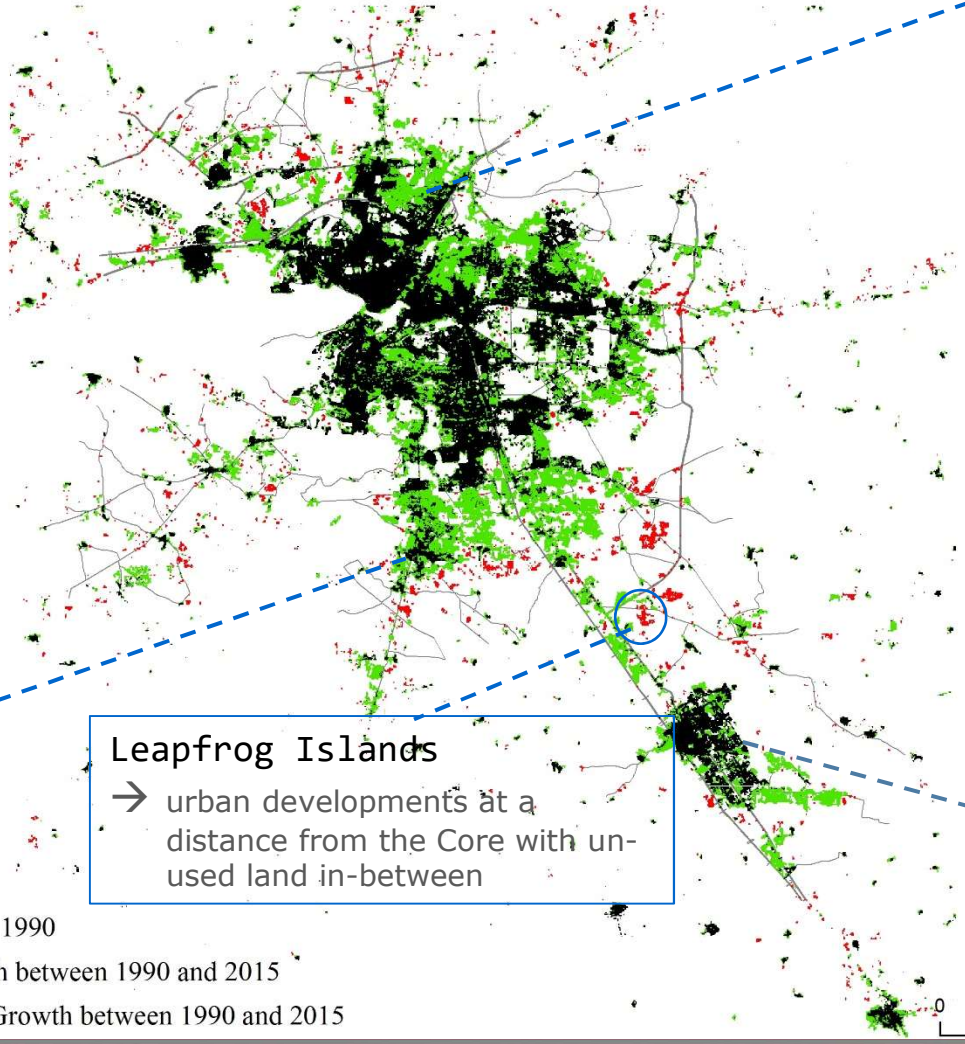
Urban Growth Patterns in Arusha City (2000 – 2015)



Bhopal: Urban Growth between 1990 – 2015



Suburbs are commonly aligned to major road infrastructure. They develop in the form of linear strips



Leapfrog Islands

→ urban developments at a distance from the Core with un-used land in-between

Densification and compaction around the inner part of the city

The process of suburbanization is guided by the reachability of regions

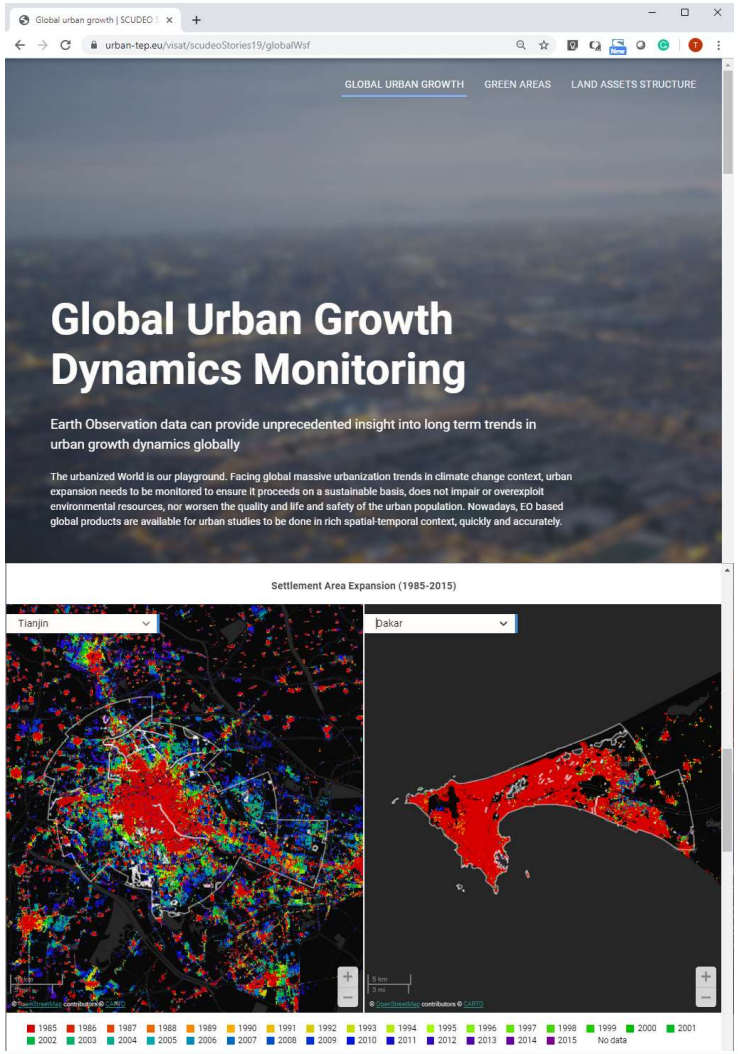
Vijayawada: Urban Growth between 1990 – 2015

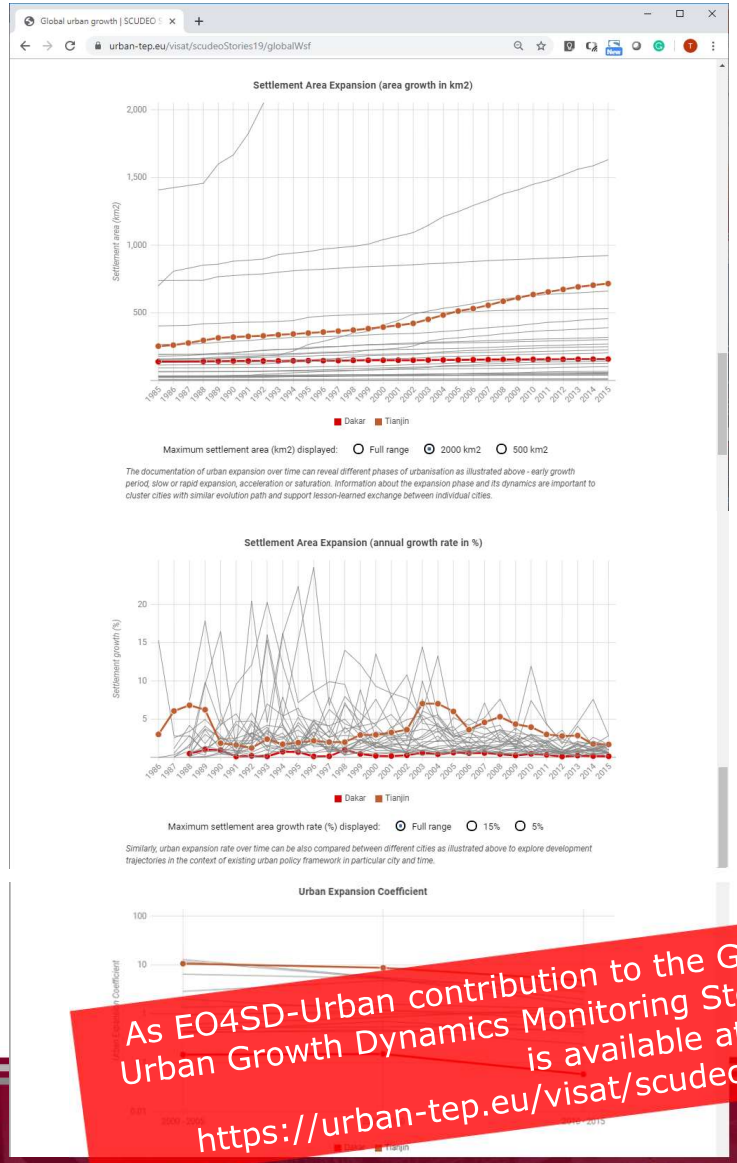
Extensive infill growth

Mainly densification and compaction around the inner part of the city

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

Urban Extent (and Change)
Global products





As EO4SD-Urban contribution to the GPSC's 3rd Global Meeting Urban Growth Dynamics Monitoring Storyline for all GPSC Cities is available at

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

Strategic / Operational level

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

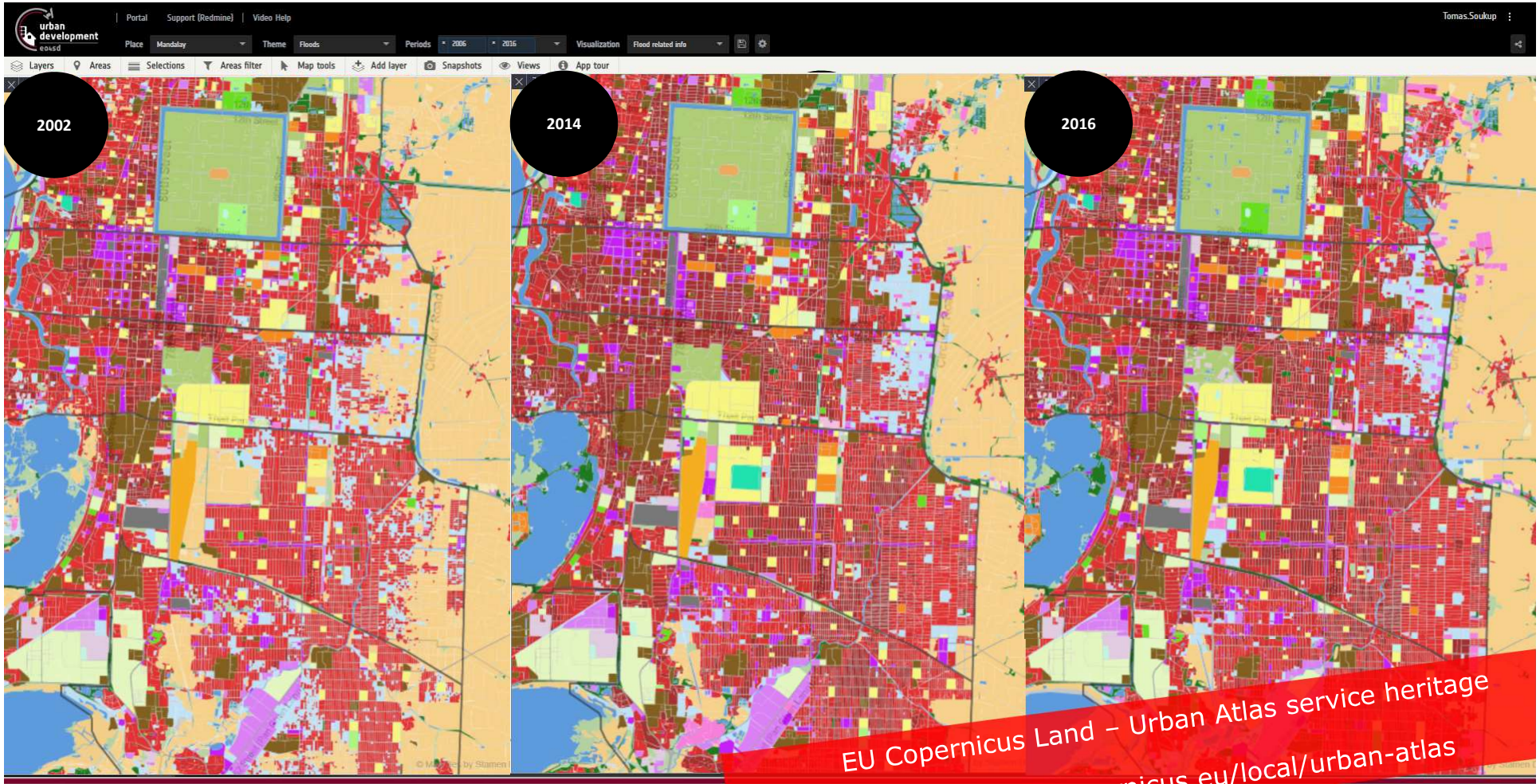
global ← → local

(Peri-) Urban Land Cover / Land Use

Regional and Detailed Products

esa

Time series – ideally in line with planning cycles



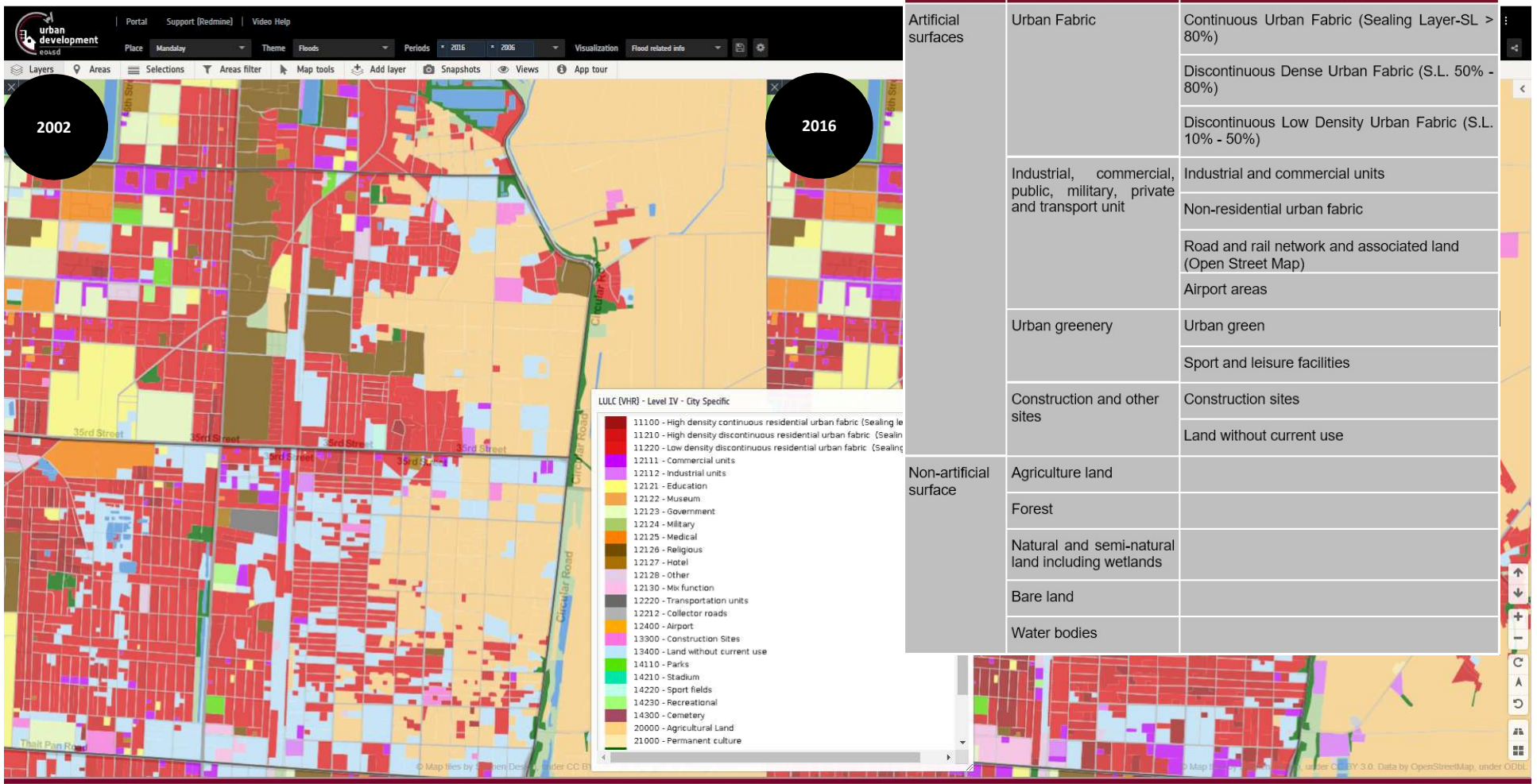
EU Copernicus Land – Urban Atlas service heritage

https://land.copernicus.eu/local/urban-atlas

(Peri-) Urban Land Cover / Land Use

Regional and Detailed Products

Standard nomenclature



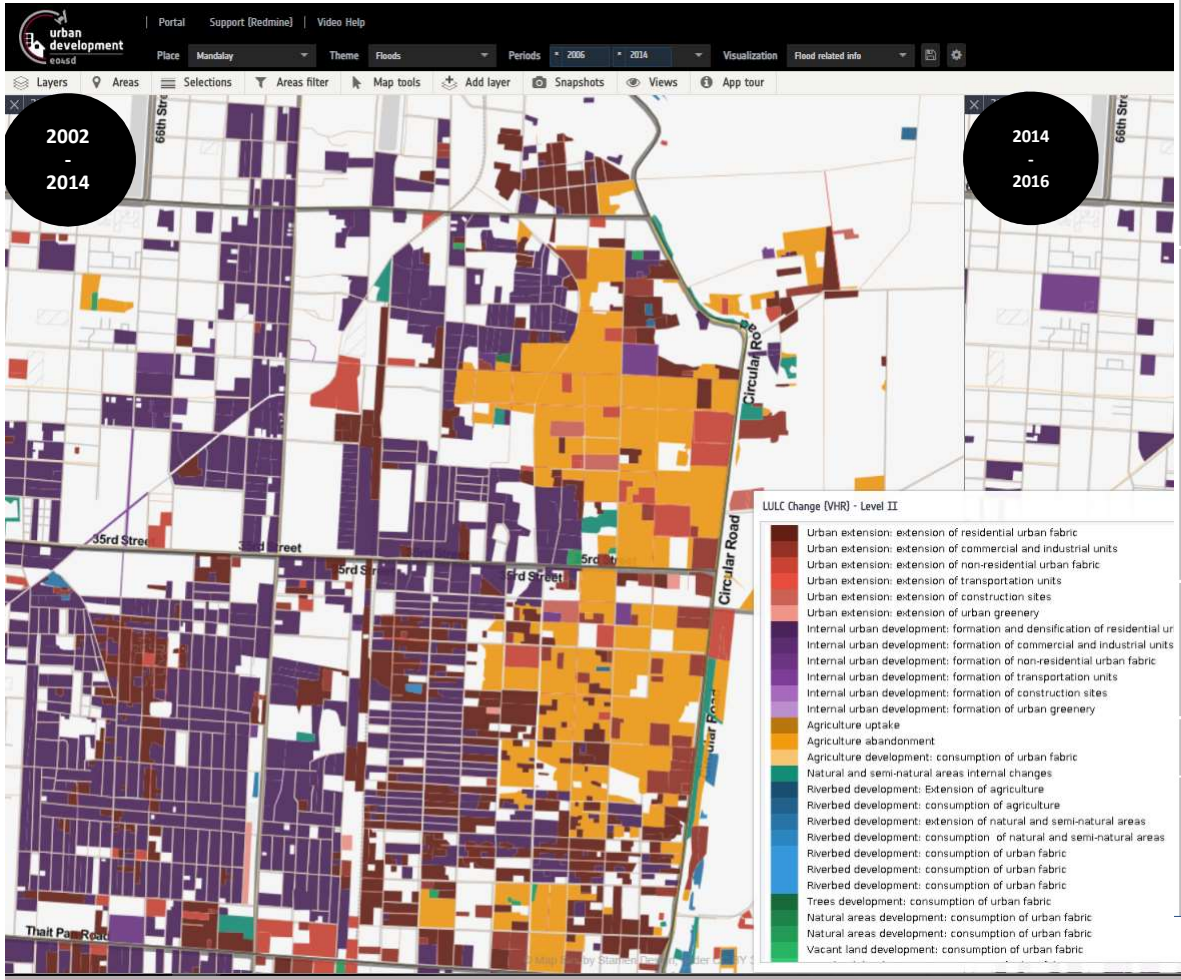
Land Cover Land Use Nomenclature (LCLU)

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



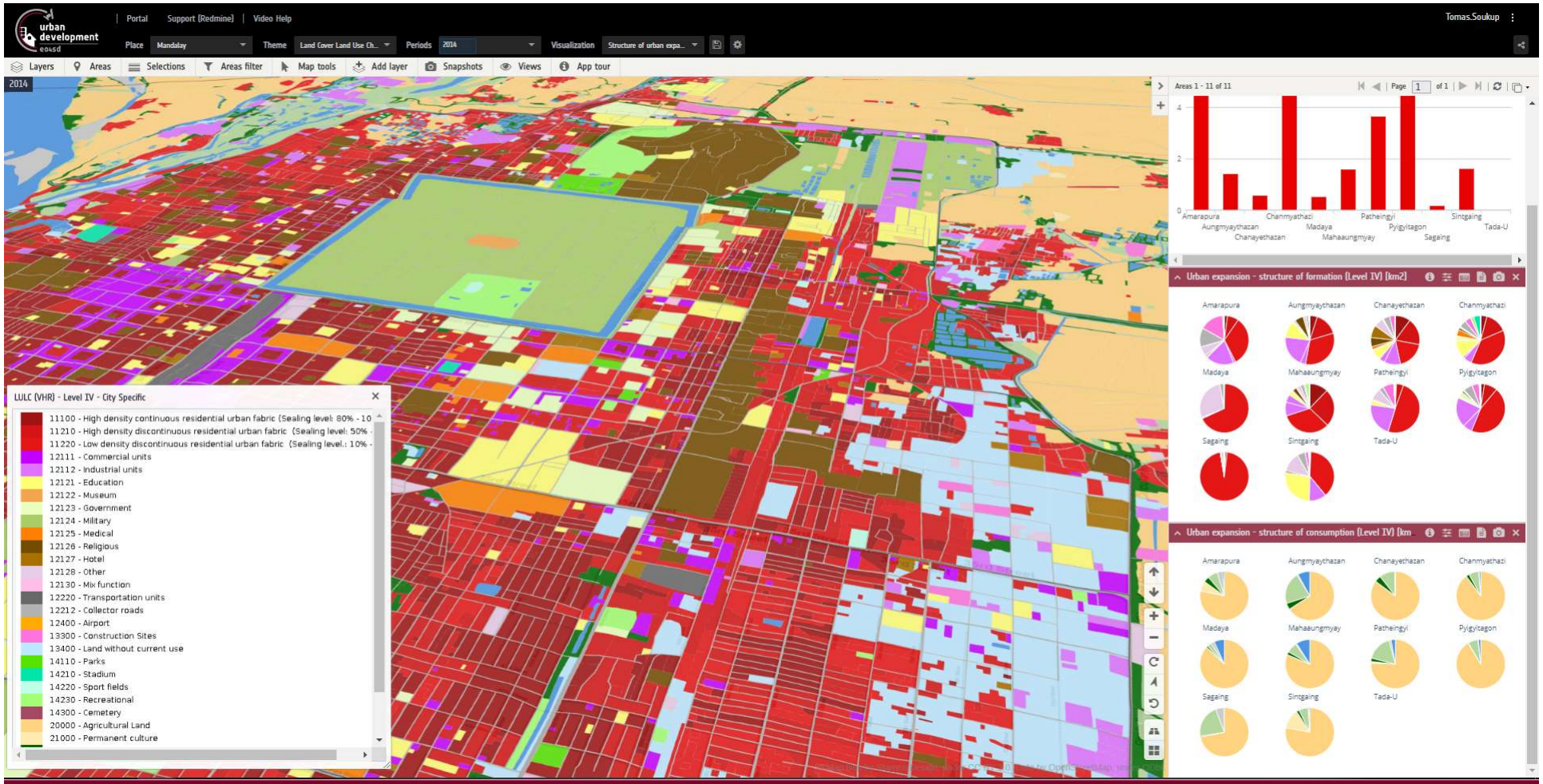
Land Cover Flows (LCF)

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 agriculture	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)

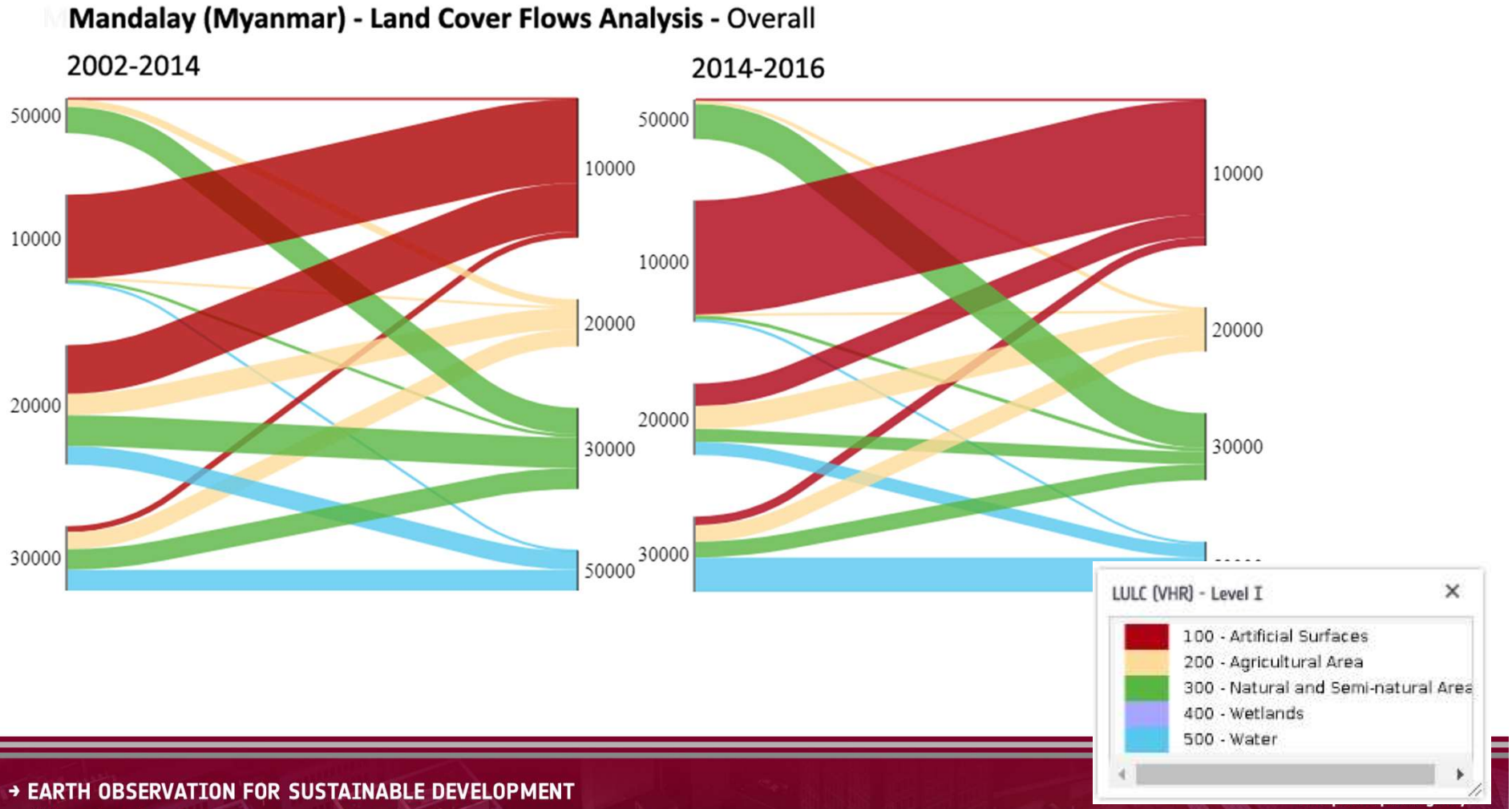
(Peri-) Urban Land Cover / Land Use

Regional and Detailed Products

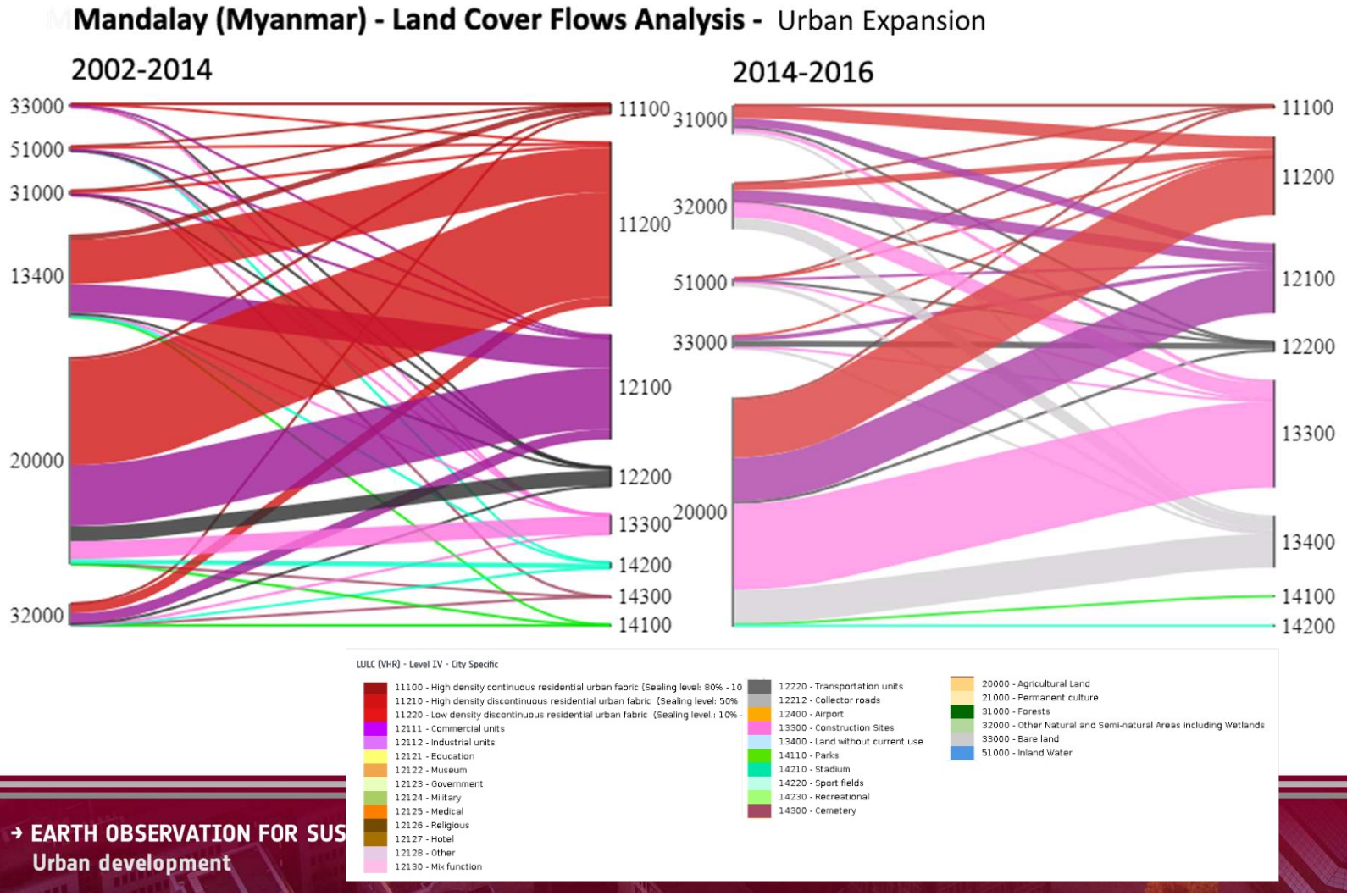
Statistics – understanding intensity and ‘cons / forms’ flows



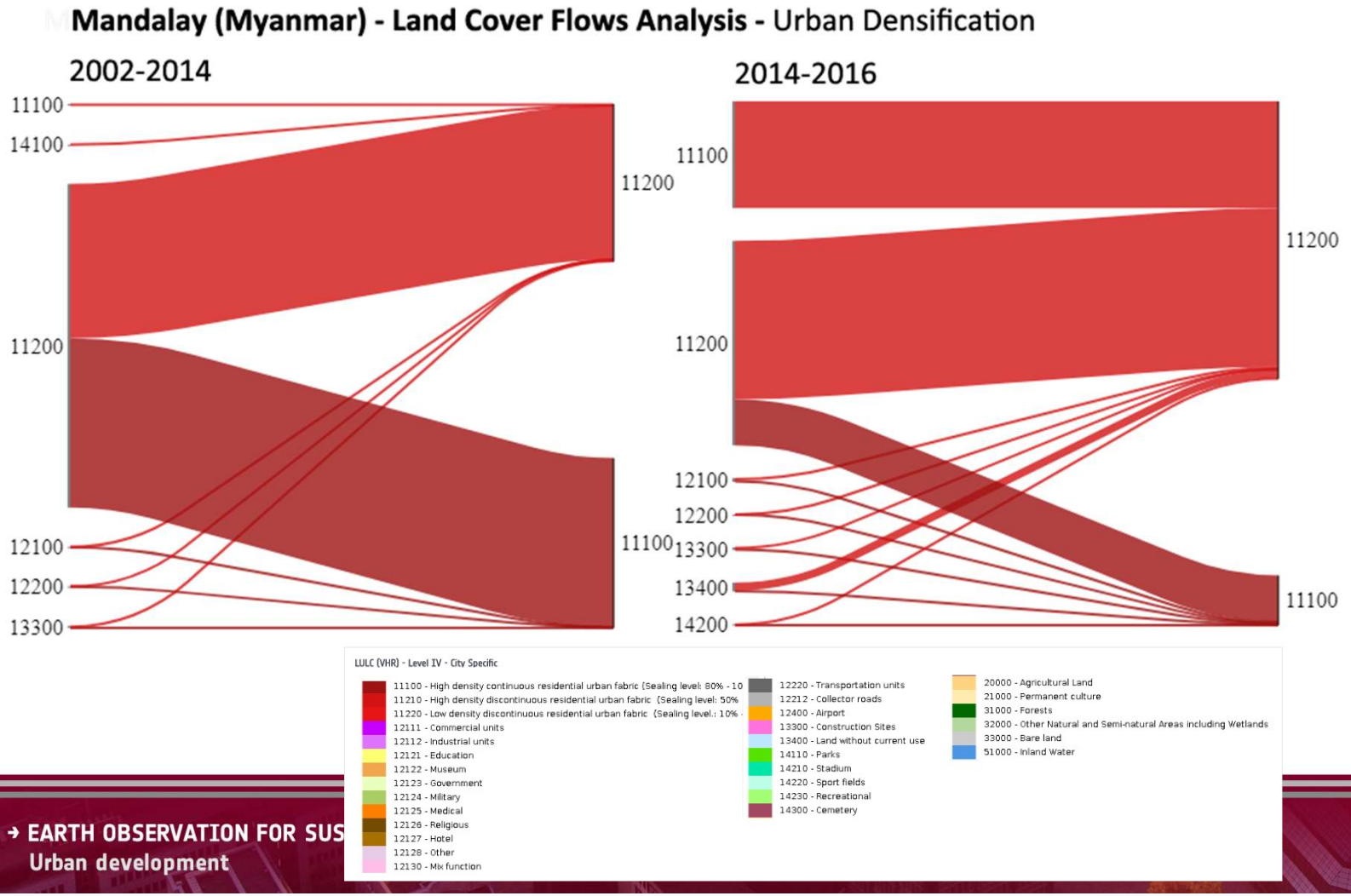
Land Assets Statistics – comparison of trends - overall



Land Assets Statistics – Trends in Urban Expansion

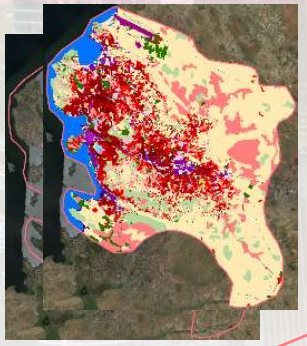


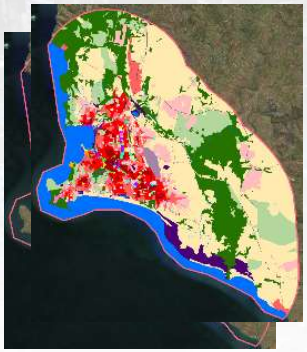
Land Assets Statistics – Trends in Urban Densification

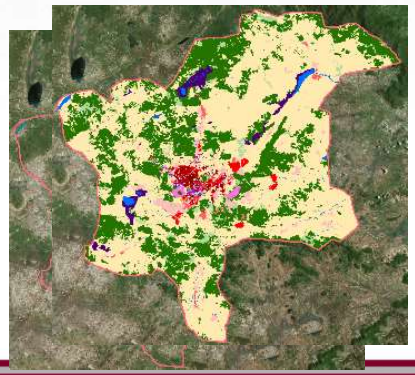


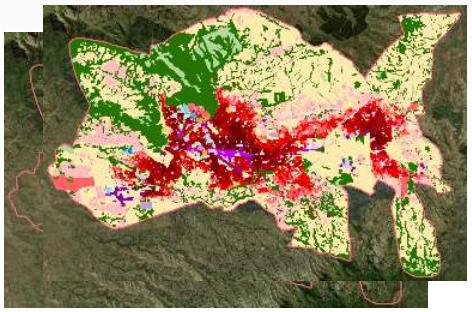
Urban Planning

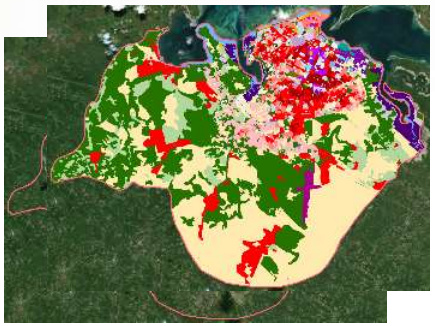
Land Use / Land Cover Maps of Tanzanian Cities

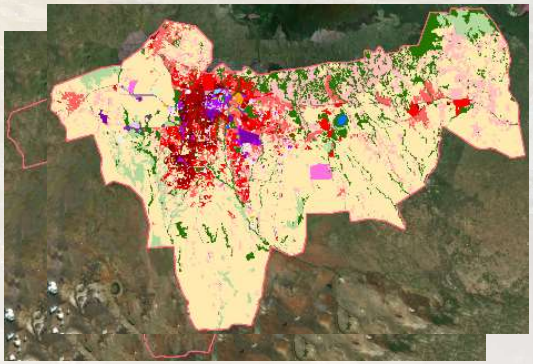


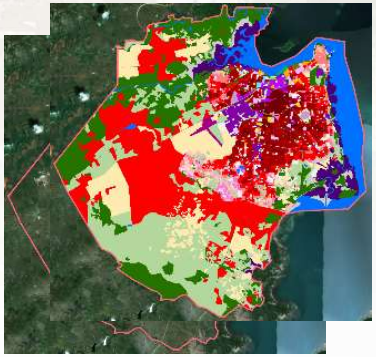


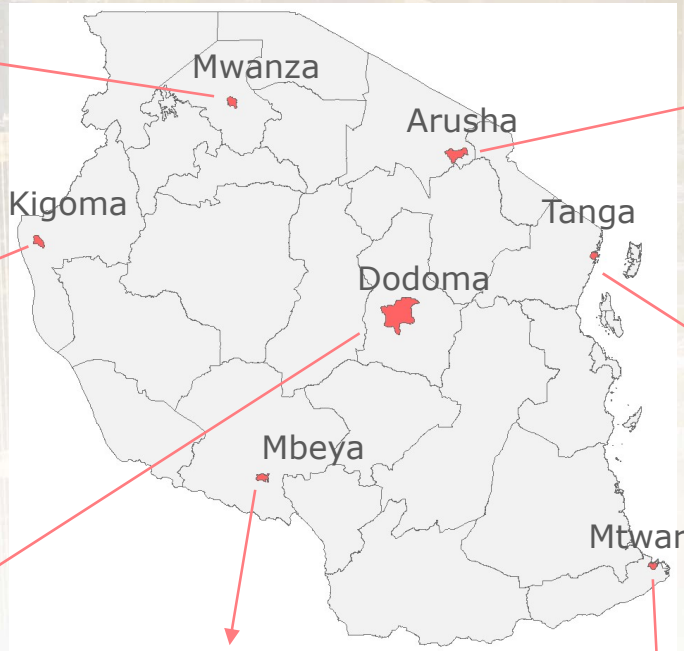








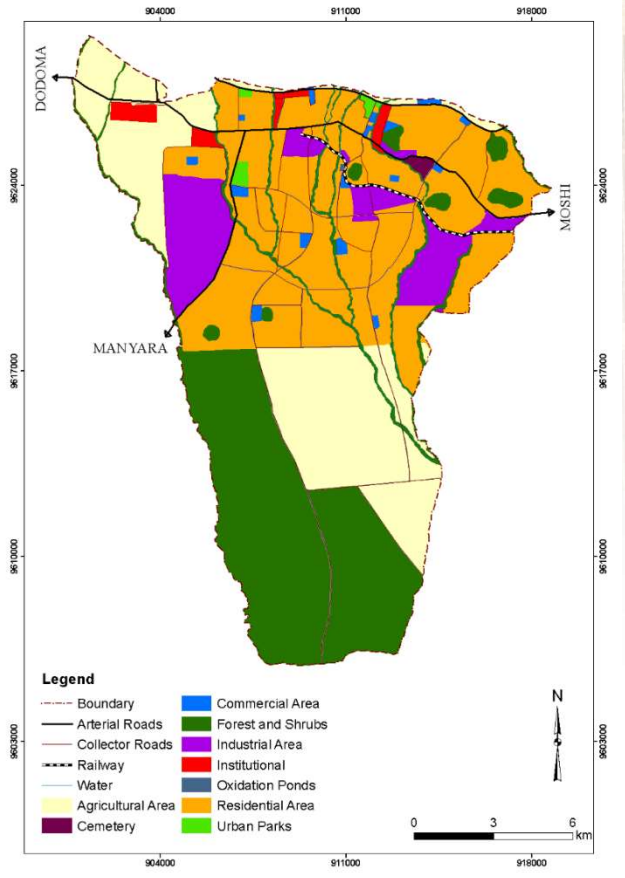




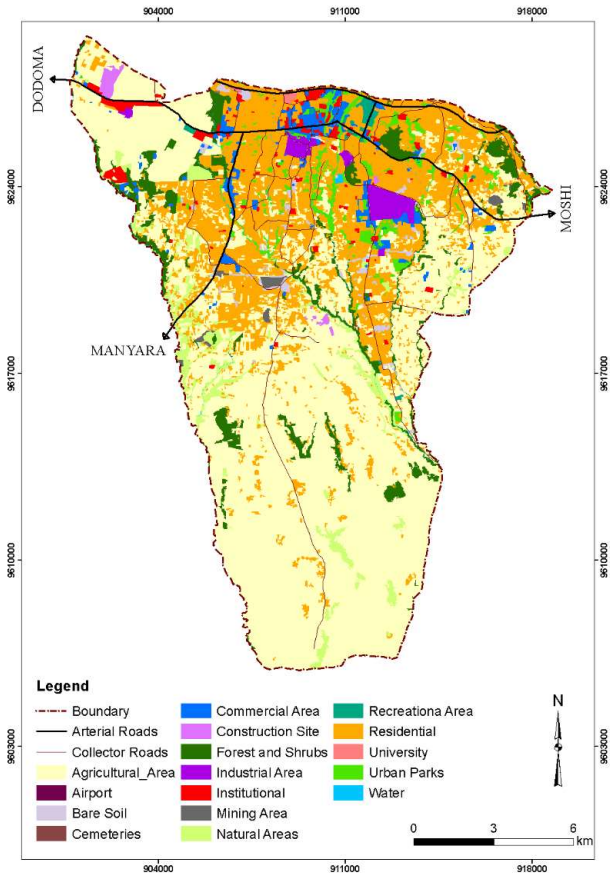
Comparative Analysis with existing Master Plan

Example Use Case – Arusha, Tanzania

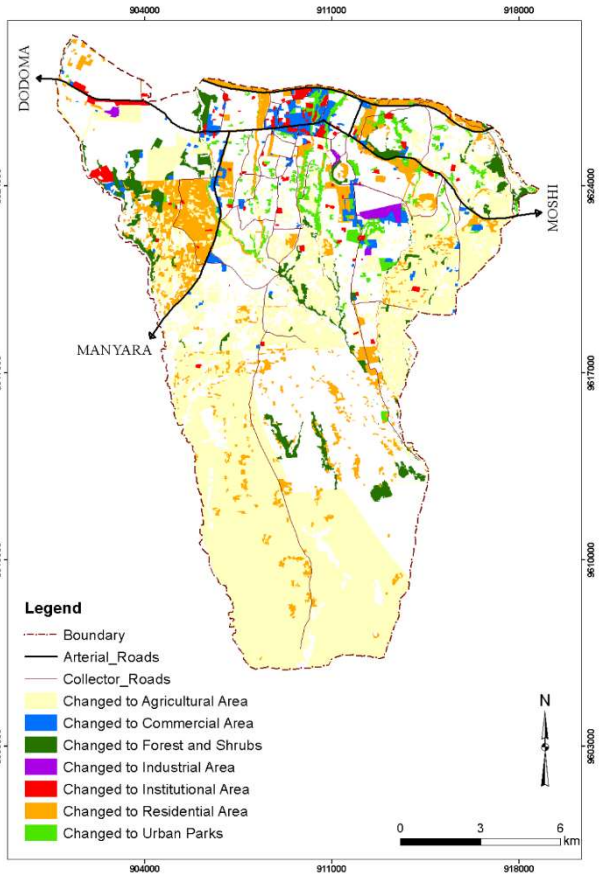
1985 Master Plan



2015 Actual Land Use

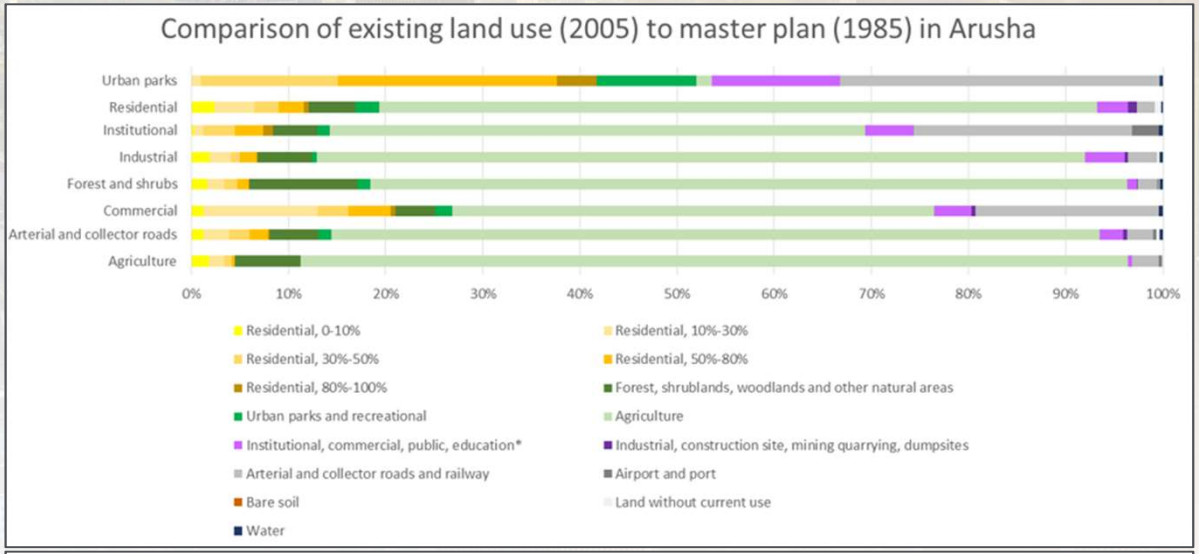


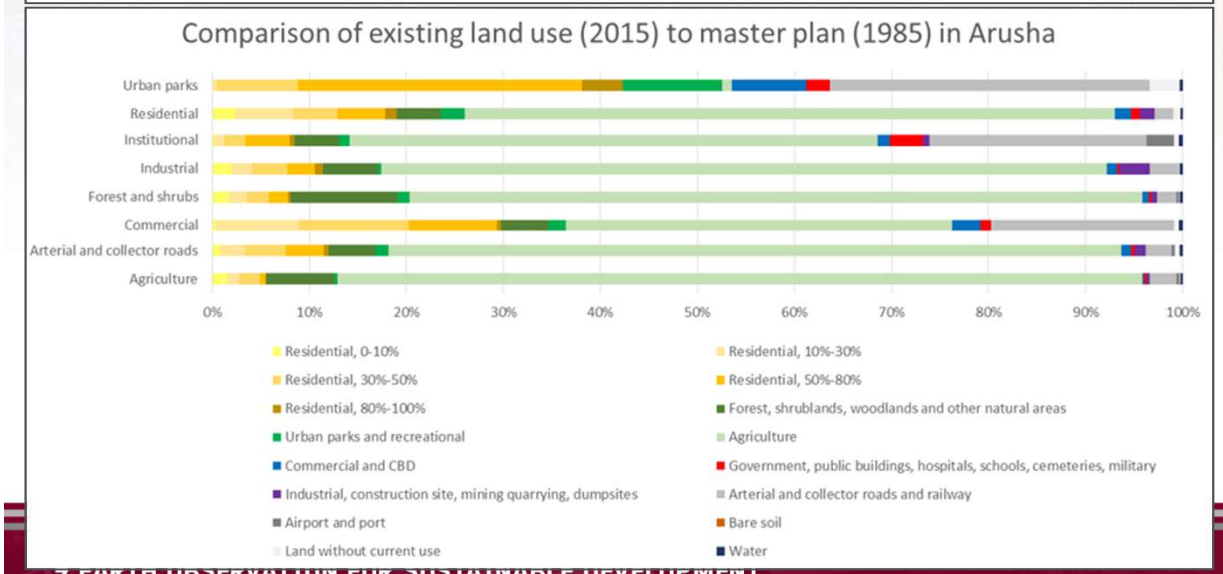
Diversion from proposed land use



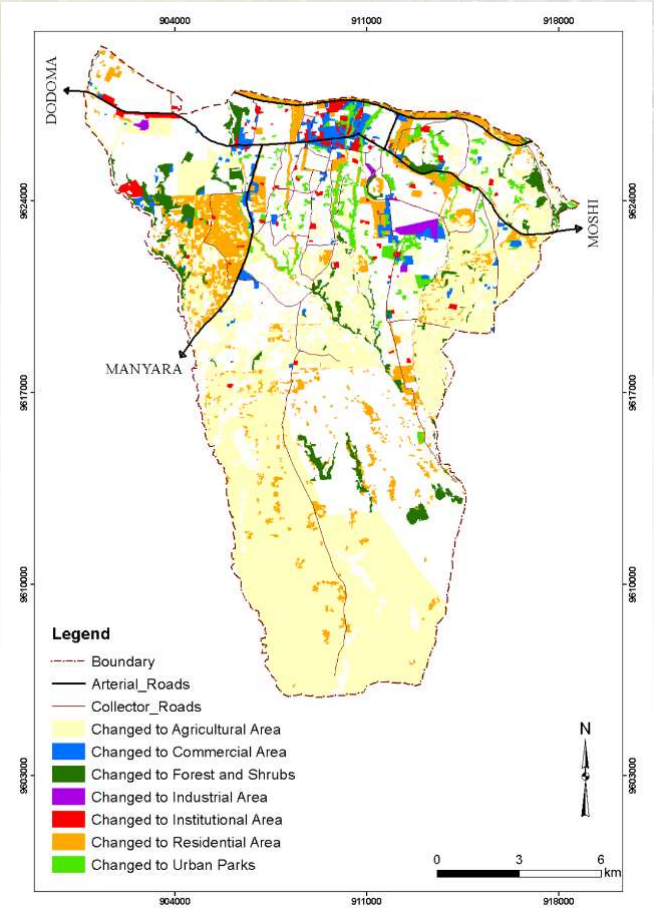
Source: Huang, C.Y. et all (2018): Translating Plans to Development, World Bank Group.

Comparative Analysis with existing Master Plan





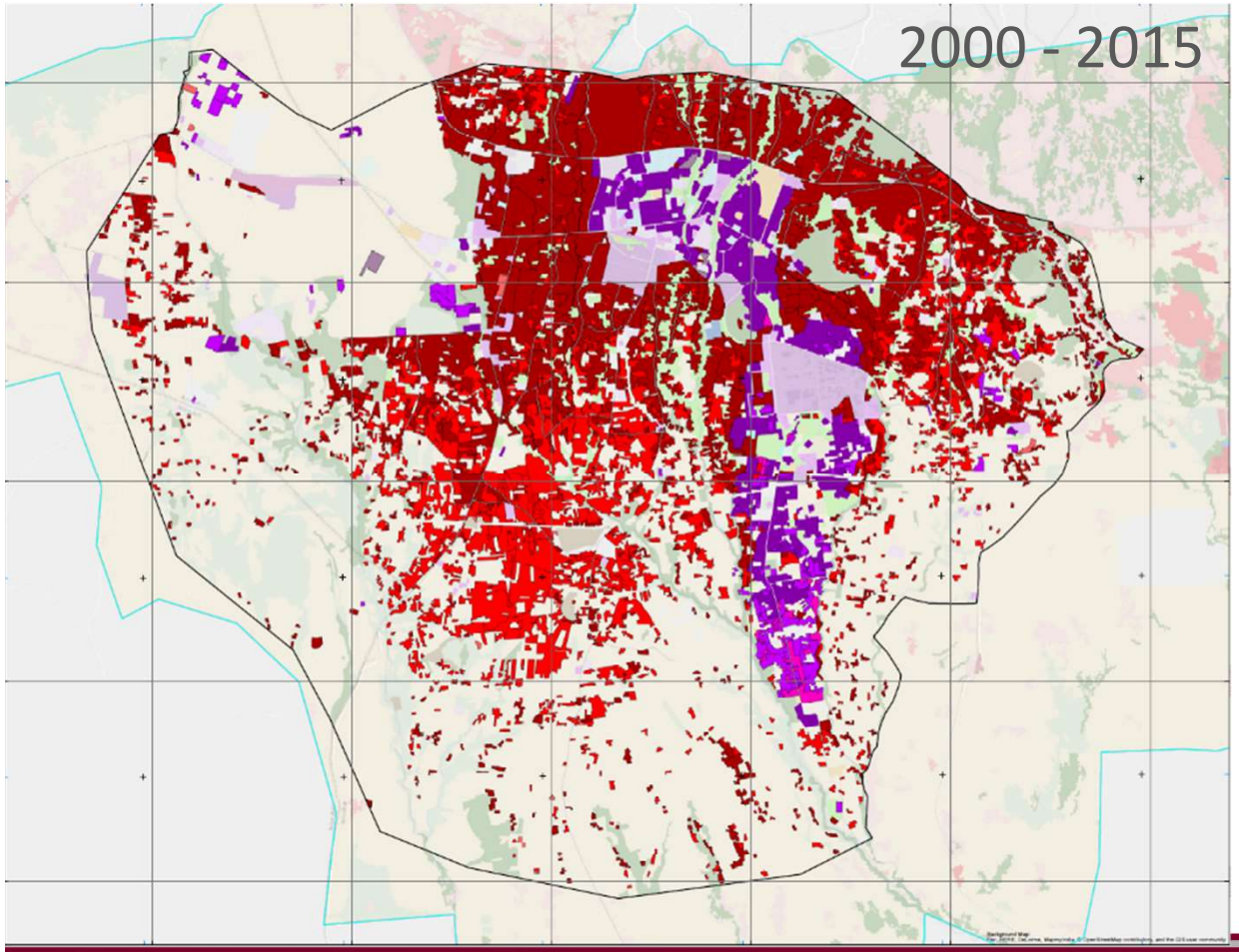
Diversion from proposed land uses



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

Planned vs Unplanned Settlements

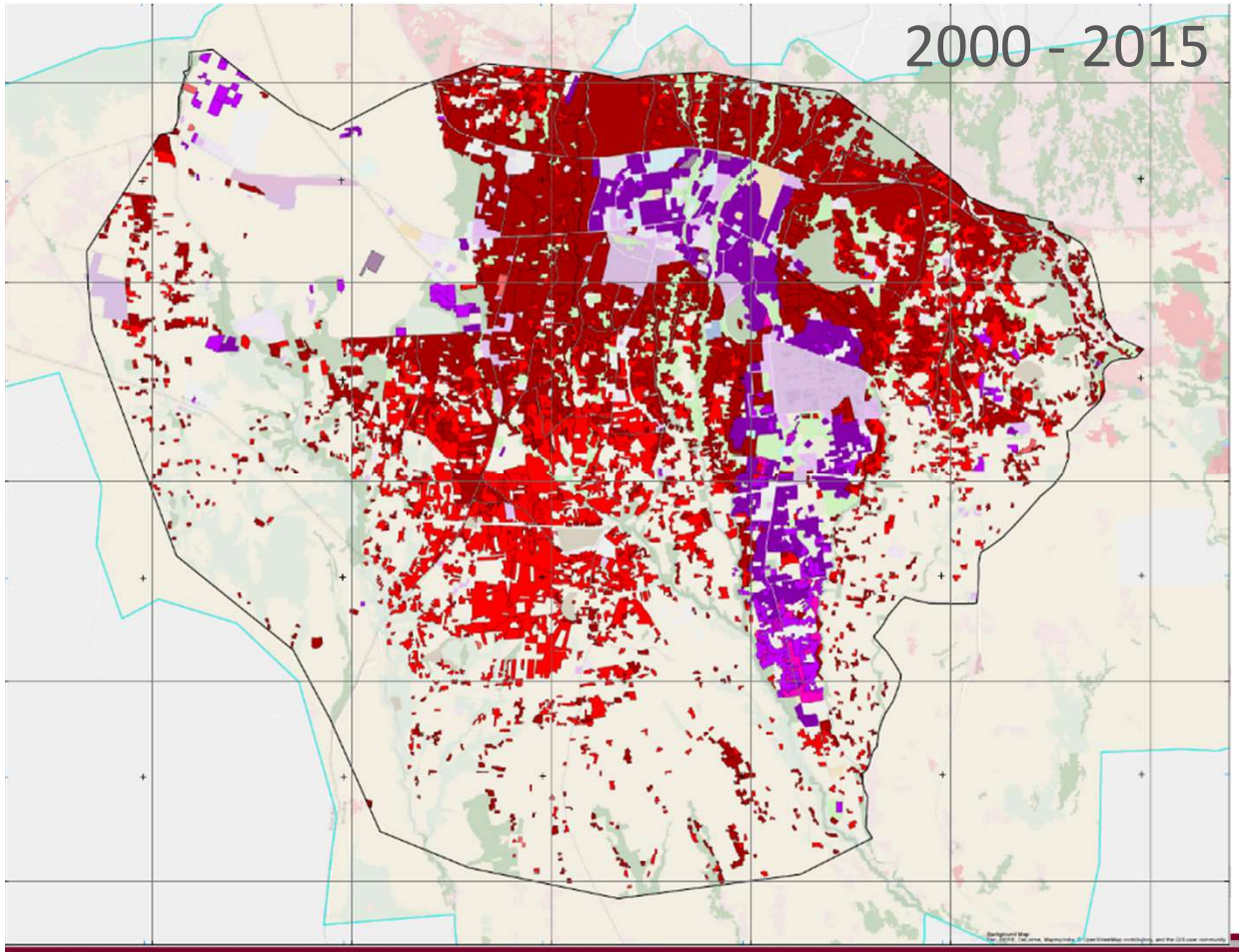
Arusha City



- 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

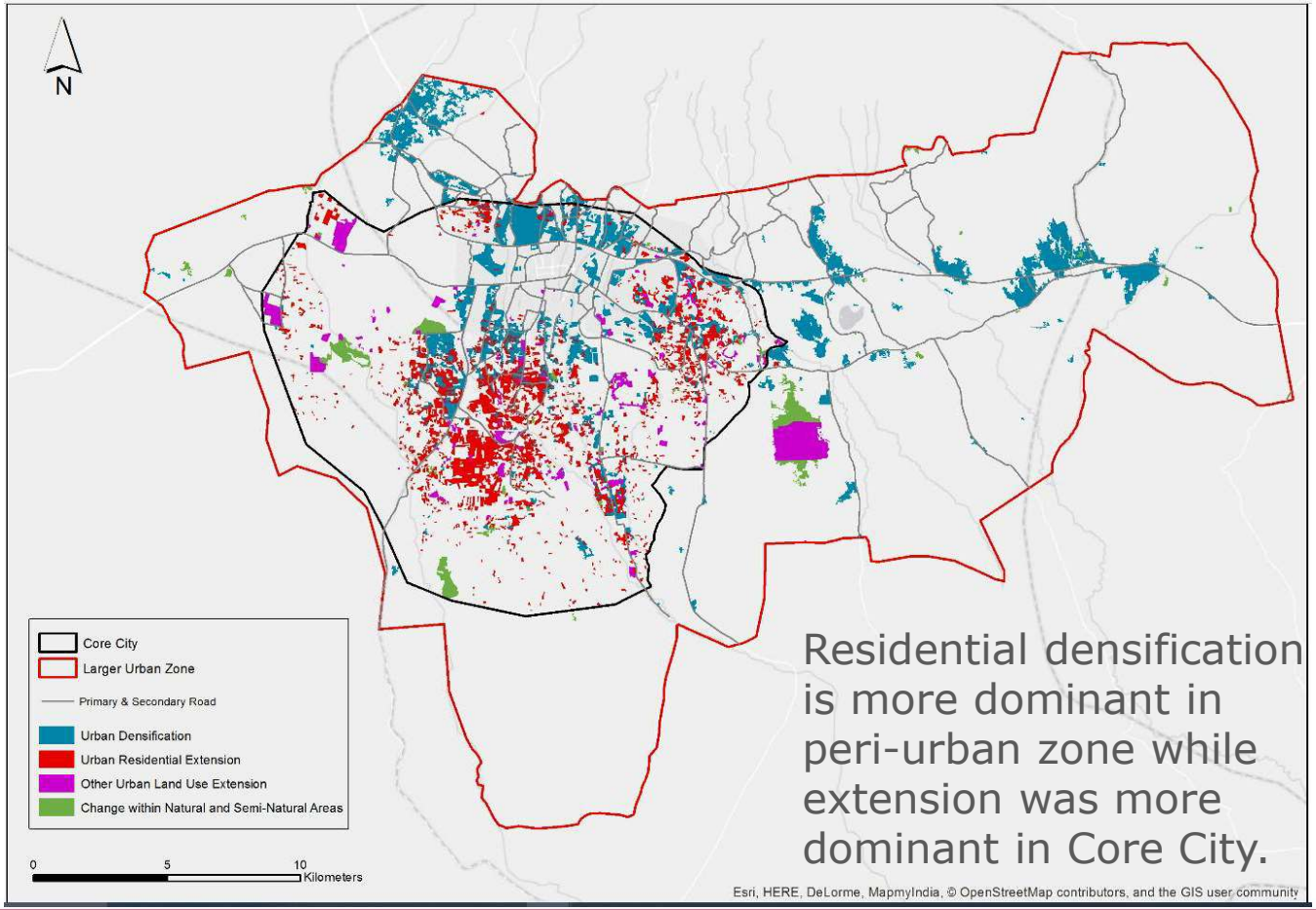
Expansion of planned settlements

No change in unplanned settlements

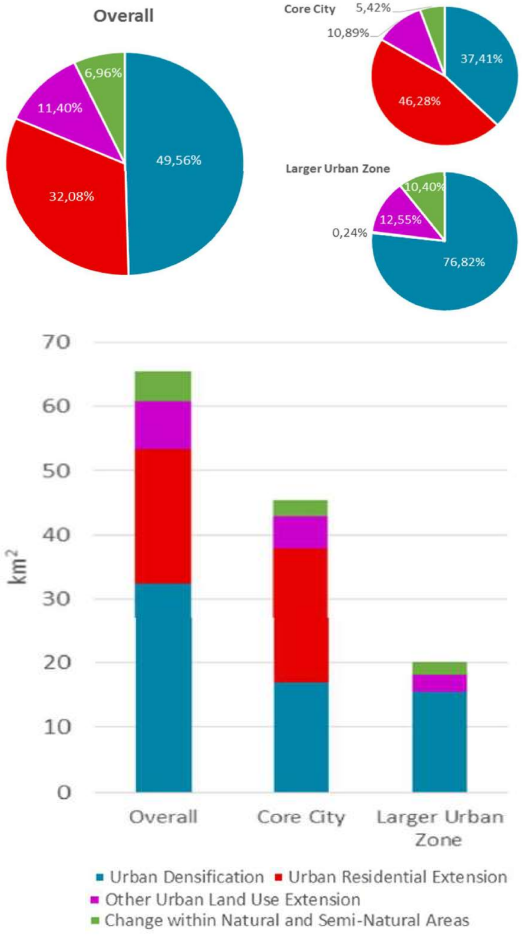
No change in planned settlements

Land Cover Distribution and Changes

Arusha City

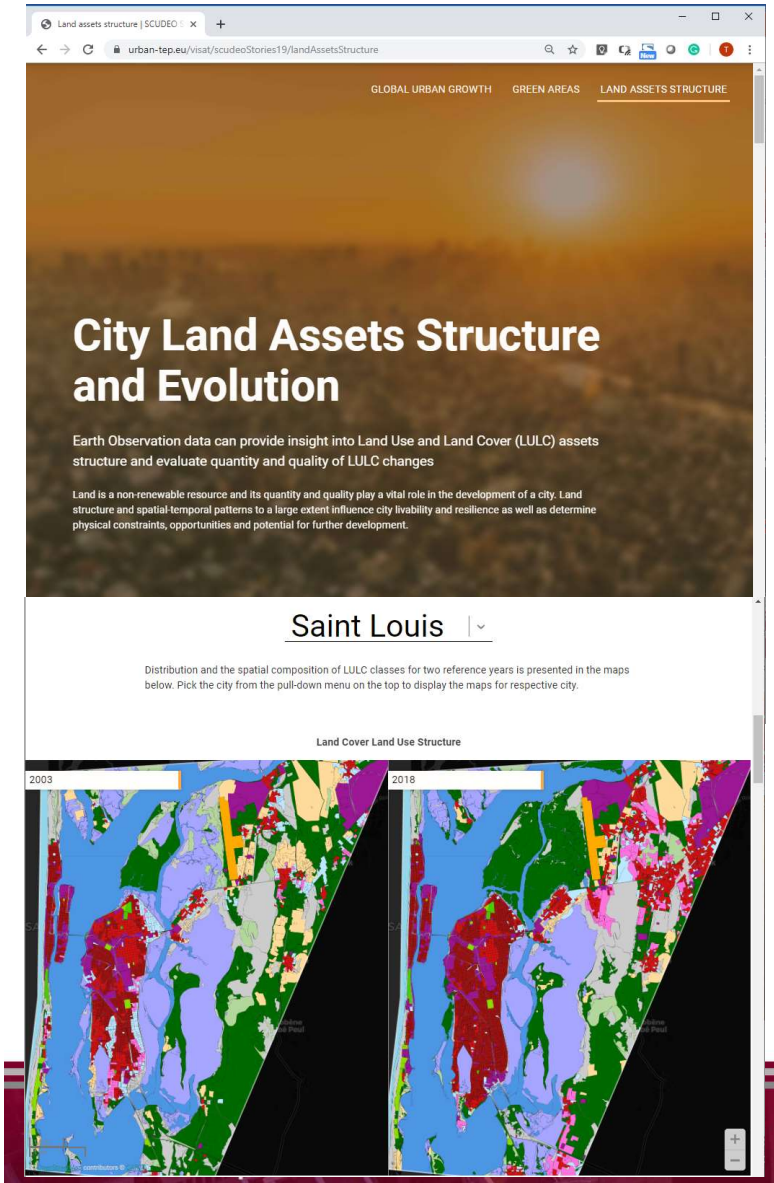


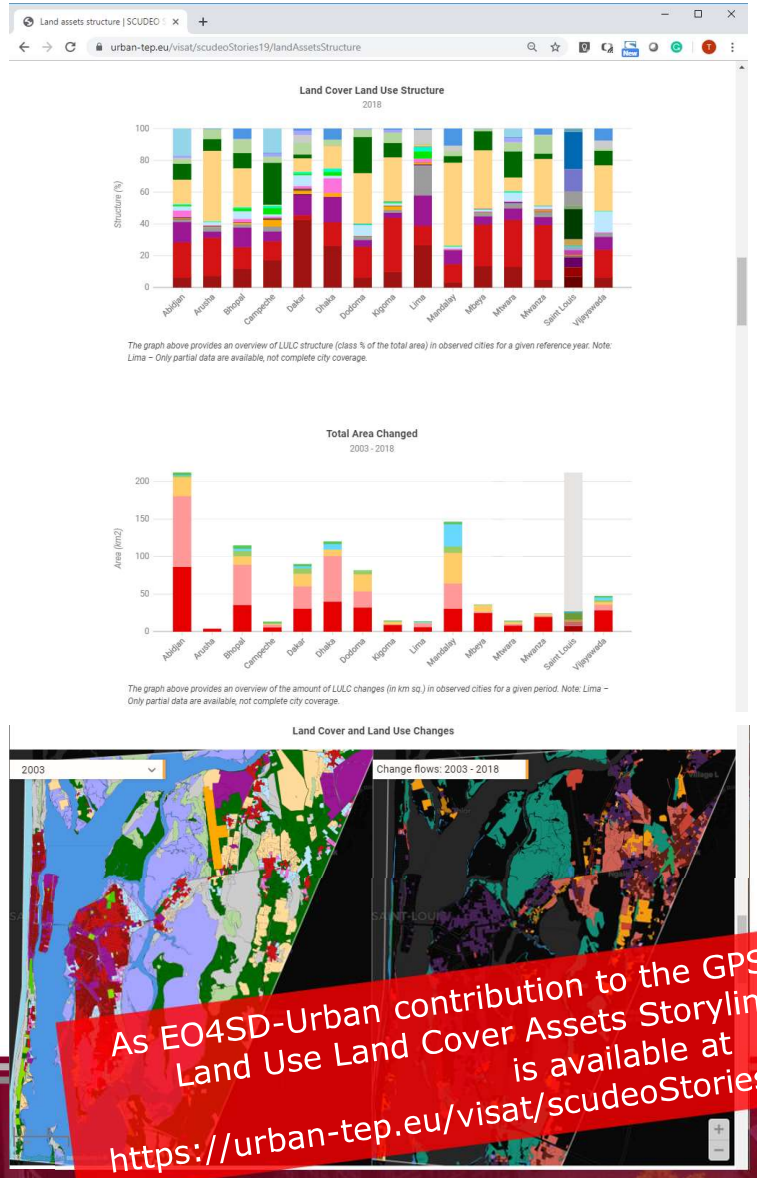
Residential densification is more dominant in peri-urban zone while extension was more dominant in Core City.



(Peri-) Urban Land Cover / Land Use

Regional and Detailed Products





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

Operational detailed level

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

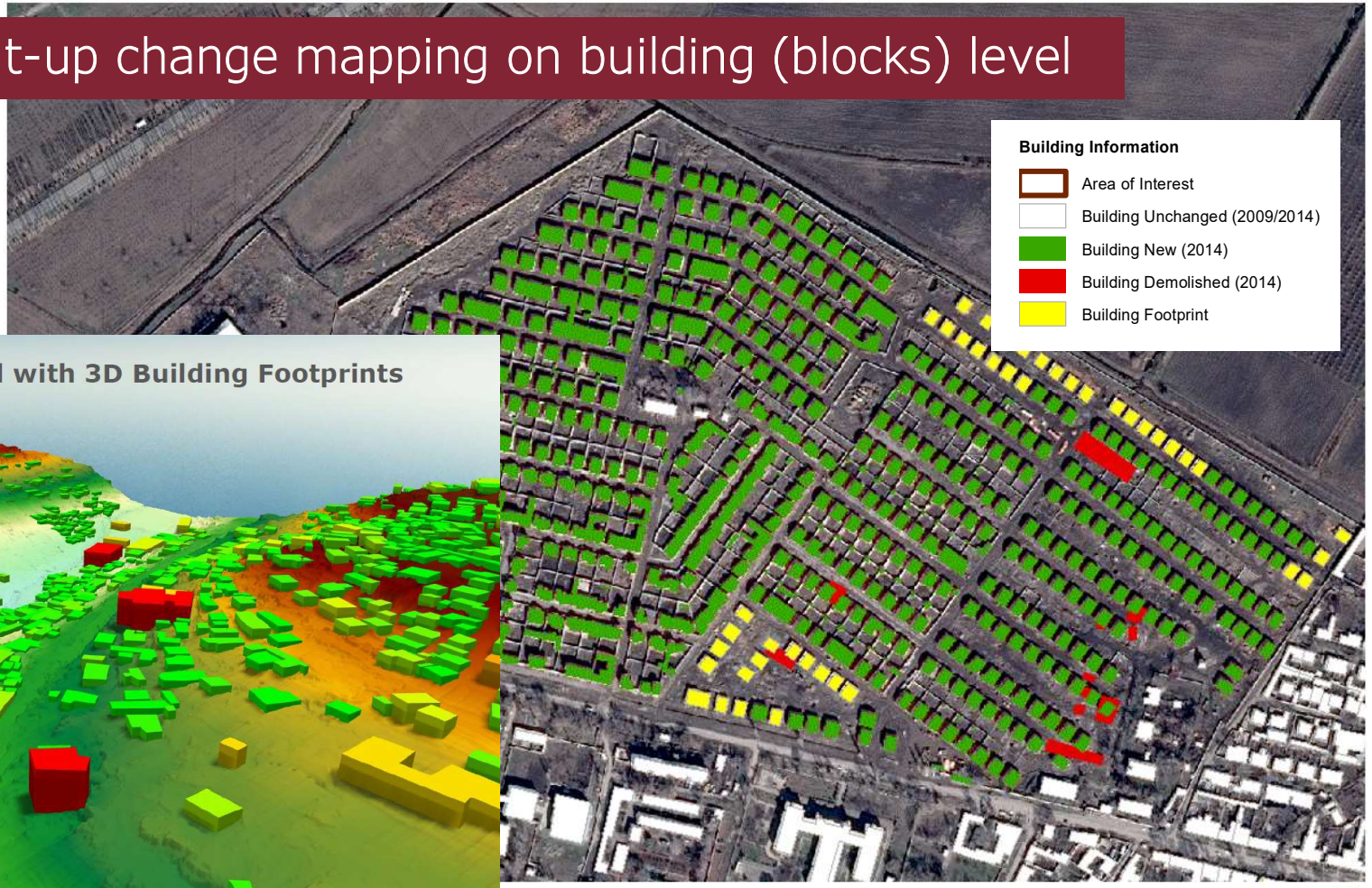
global ← → local

Building Footprints

Very Detailed Local Product

esa

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



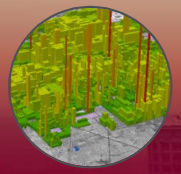
GAFAG

Building Footprints

Very Detailed Local Product

Structural indicators on individual buildings level

gisat



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

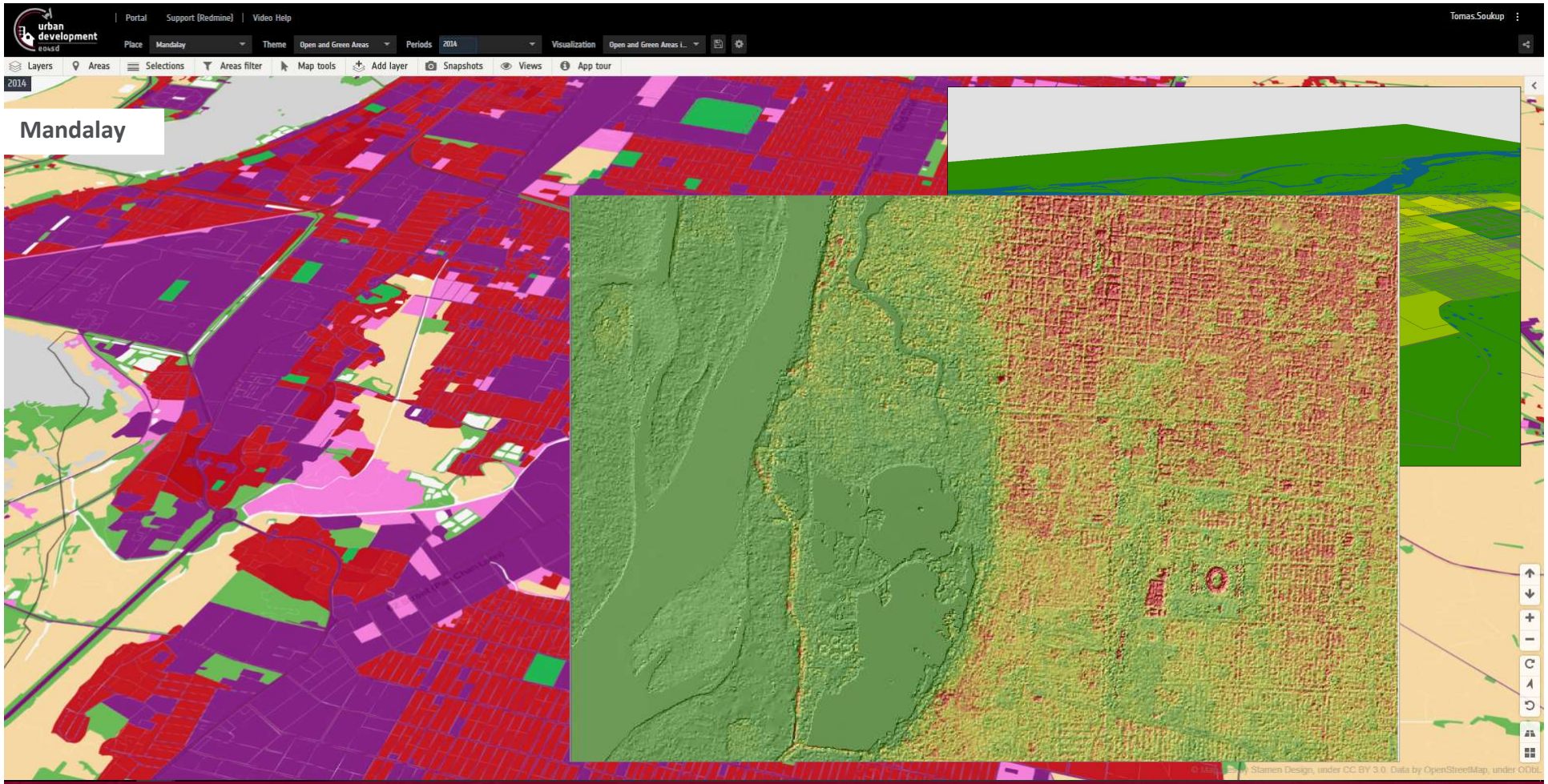
LULC, Census Data and VHR DSM for urban blocks

Population Density
Local Product

LULC, Census Data and VHR DSM for urban blocks

Population Density
Local Product

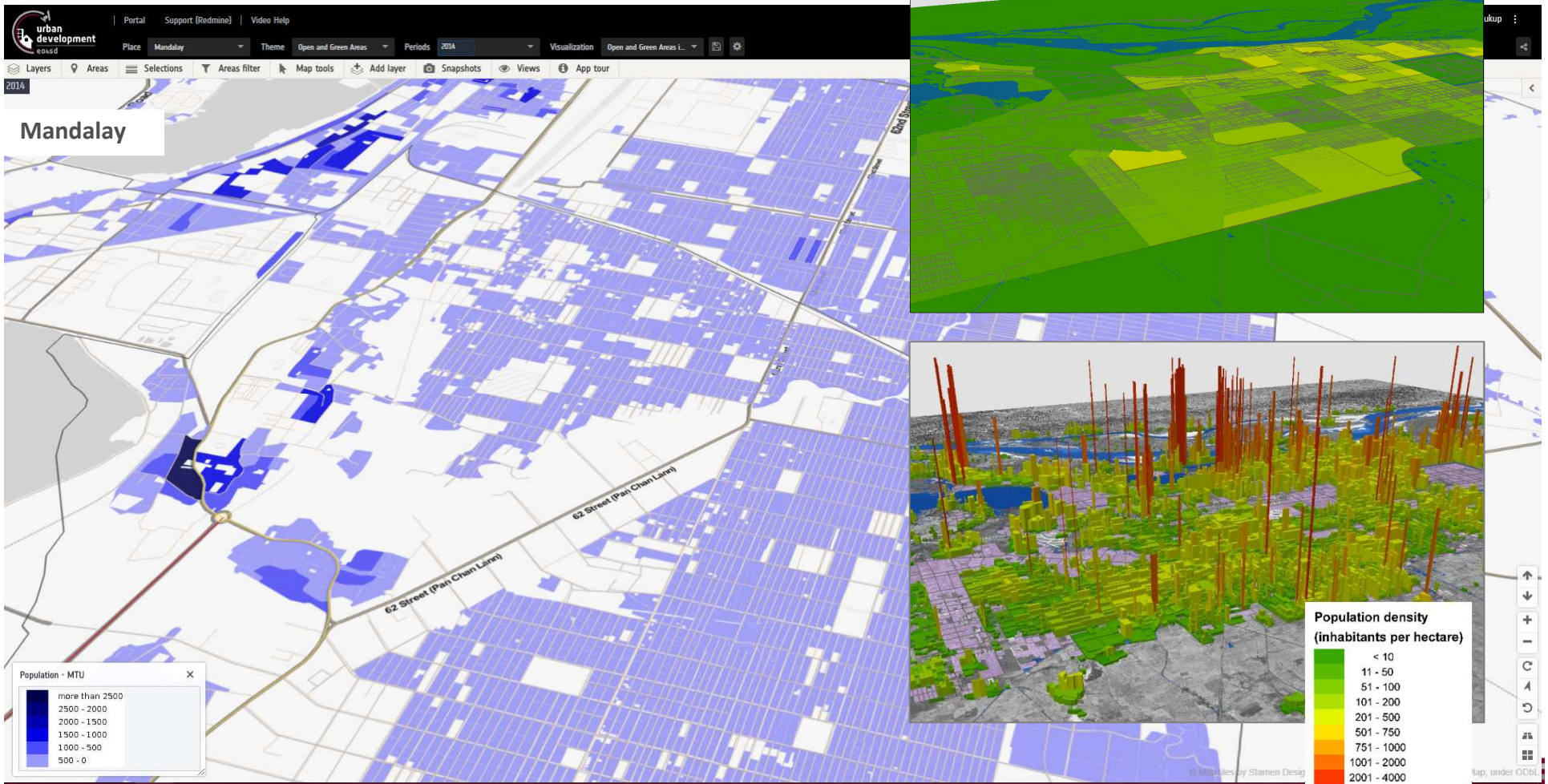
LULC, Census Data and VHR DSM for urban blocks



Population Density
Local Product

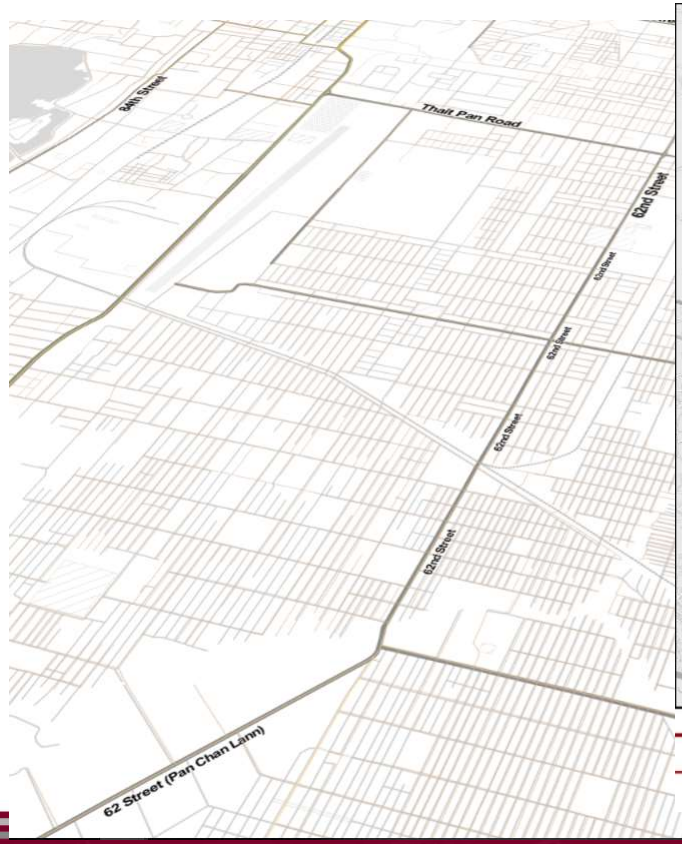
esa

Population census disaggregation

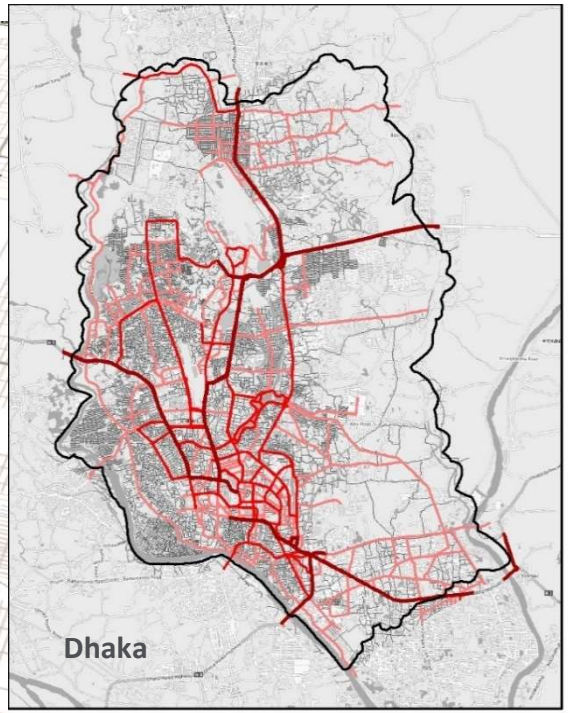


Transport

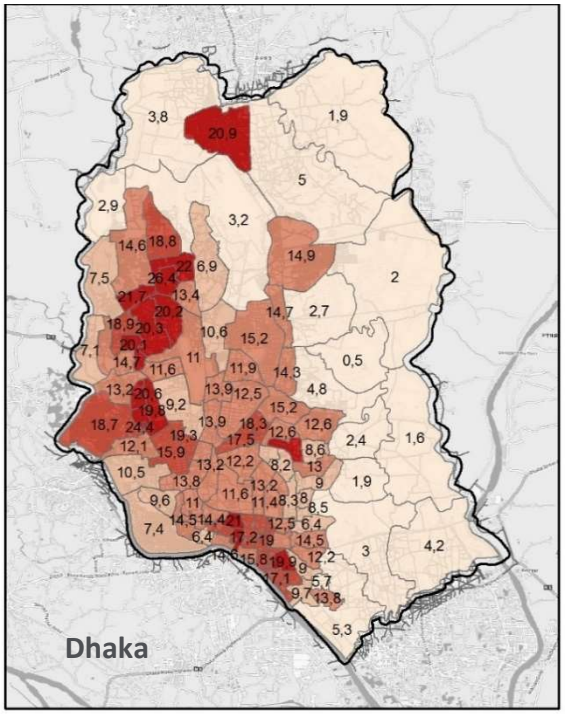
A street density (road surface / total area) gives a quick understanding about the typology of the City.



Transportation network map



Network density



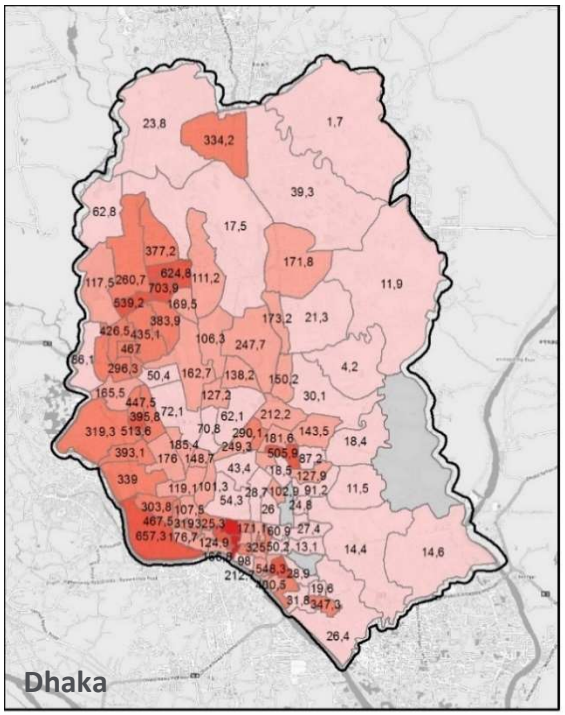
Transport

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

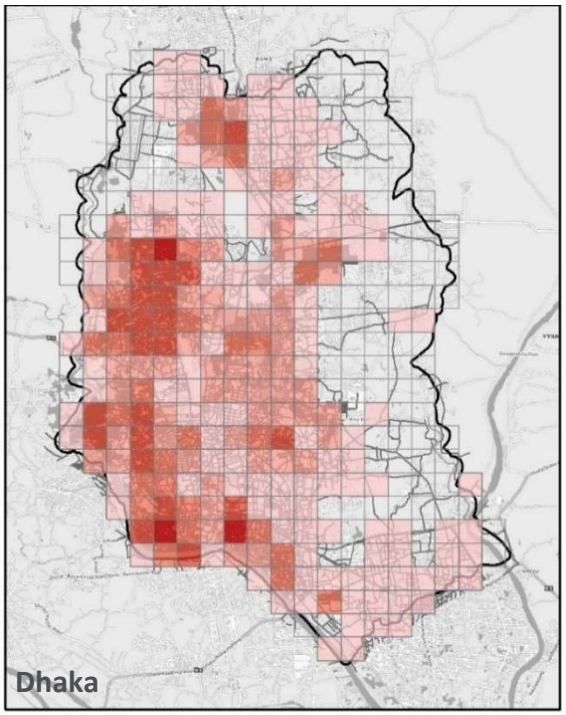
Streets and public spaces support the livelihoods of many residents, such as vendors, and facilitate social interaction within communities.

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

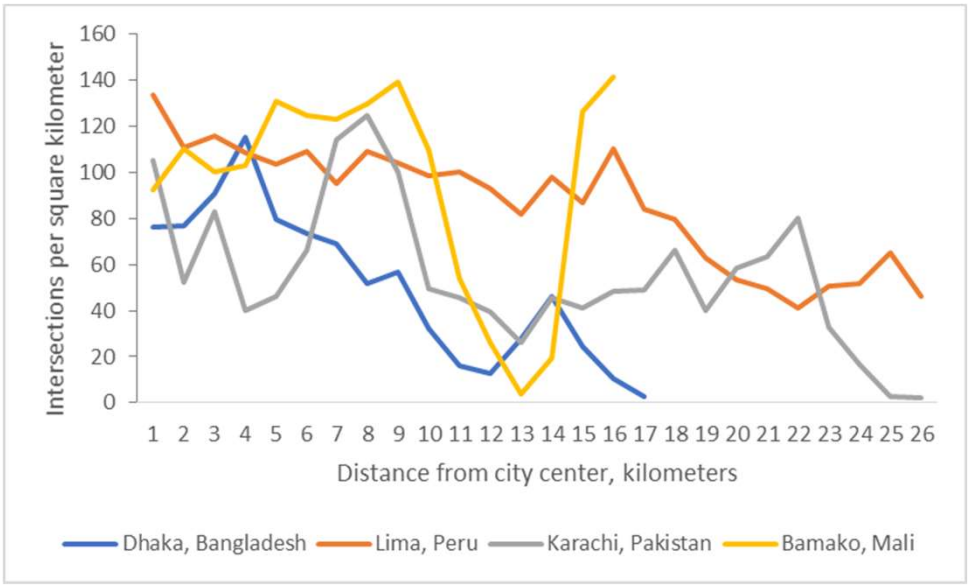
0 1200 0 5 km

Transport

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^2 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.

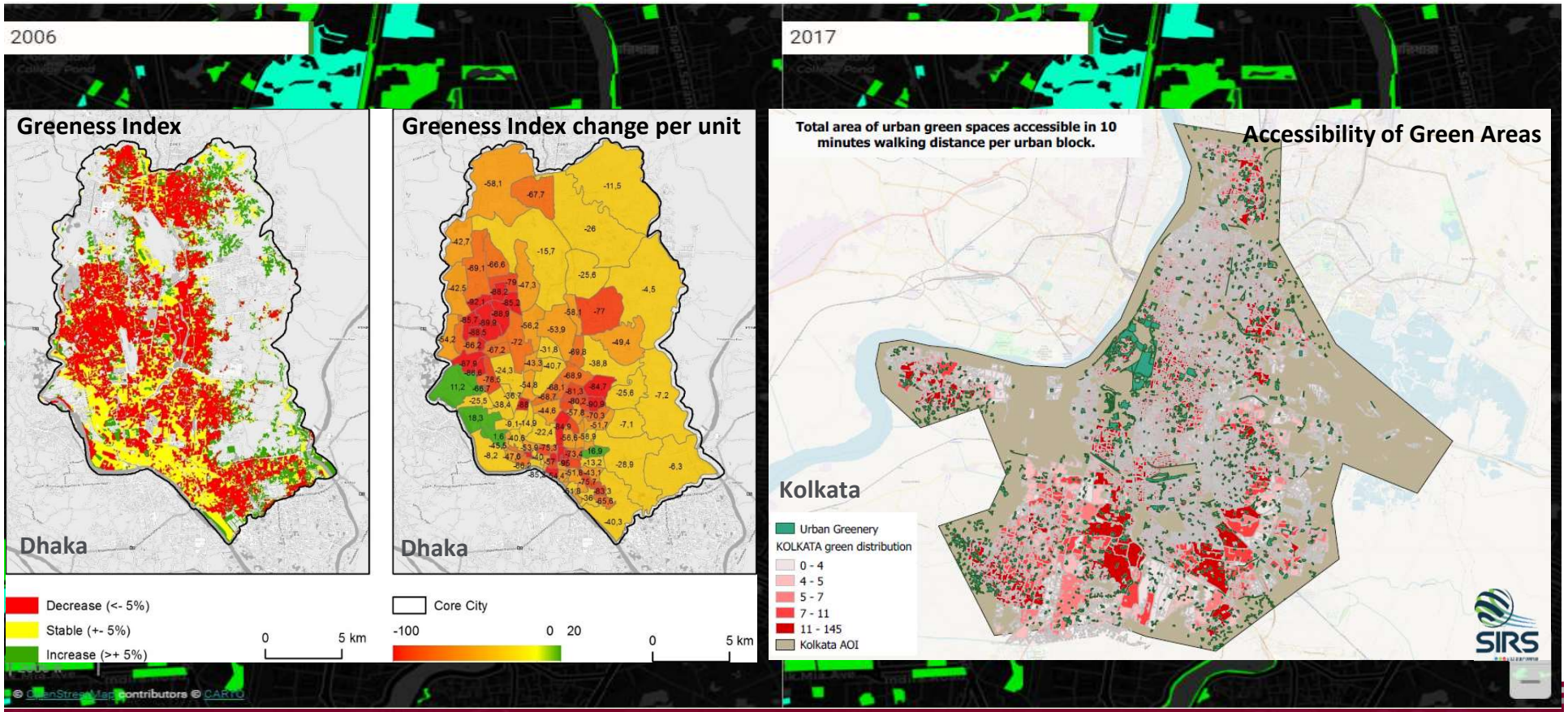
Intersection density / urban fabric / distance from the centre (CBD)



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

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

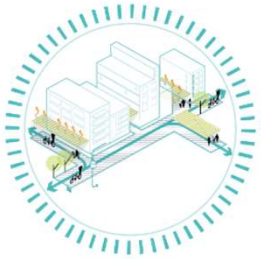
Public Space - How far we can go remotely ?

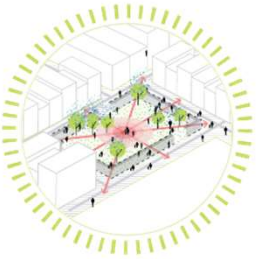
Service: Identification, quantification and characterization of potential public_urban spaces (using EO)

Coherent with SDG 11.7 implementation (UN-HABITAT)

Urban Spaces:

- Open and Green Spaces
- Streets
- Building



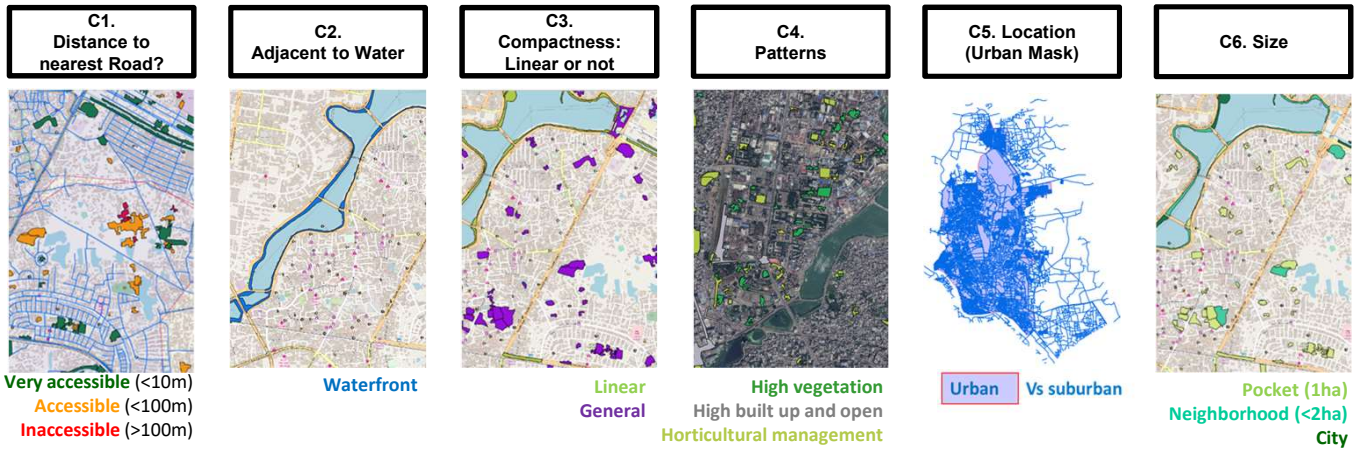


Public Space – Green and Open Areas

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

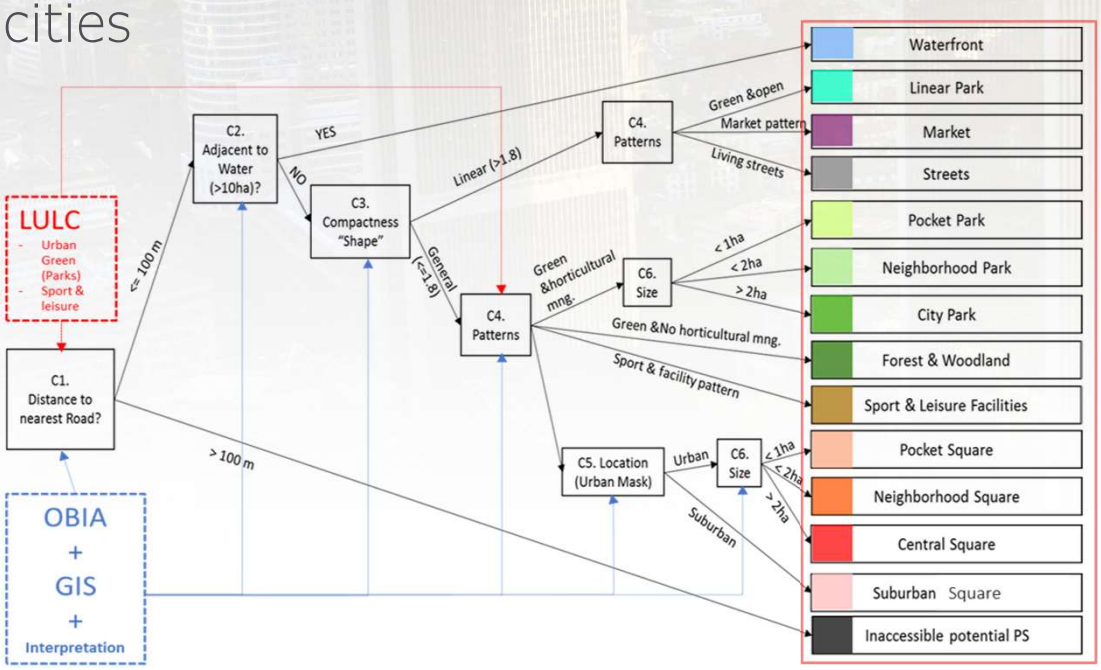
Indicator group	*Indicator*
Distance and accessibility	Distance to roads, ammenities
	Distance to water
Patterns	Shape linearity, size, compactness
	Vegetation typology (high,low, bare)
	Park probability indicator
	LULC patterns and proportions
Contextual	Built-up proportions and adjacency
	LULC adjacency

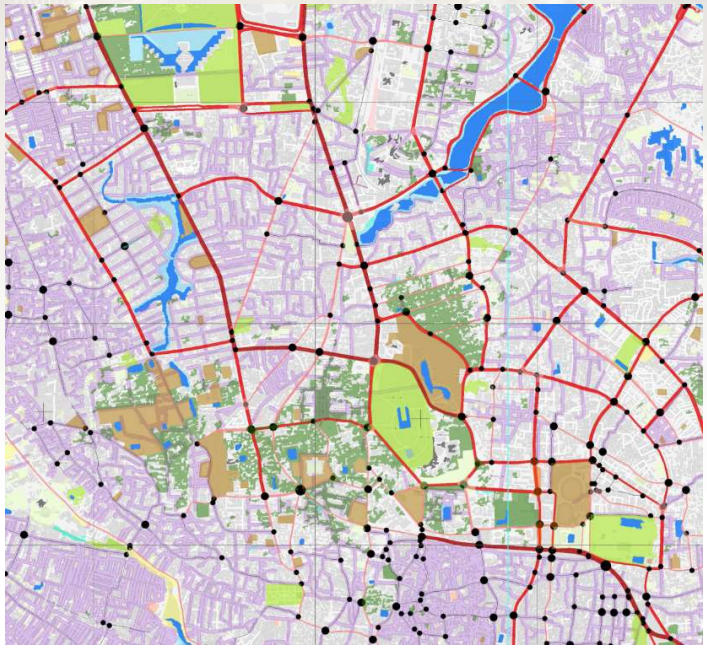


Public Space – Green and Open Areas

Rule-based GOA typology

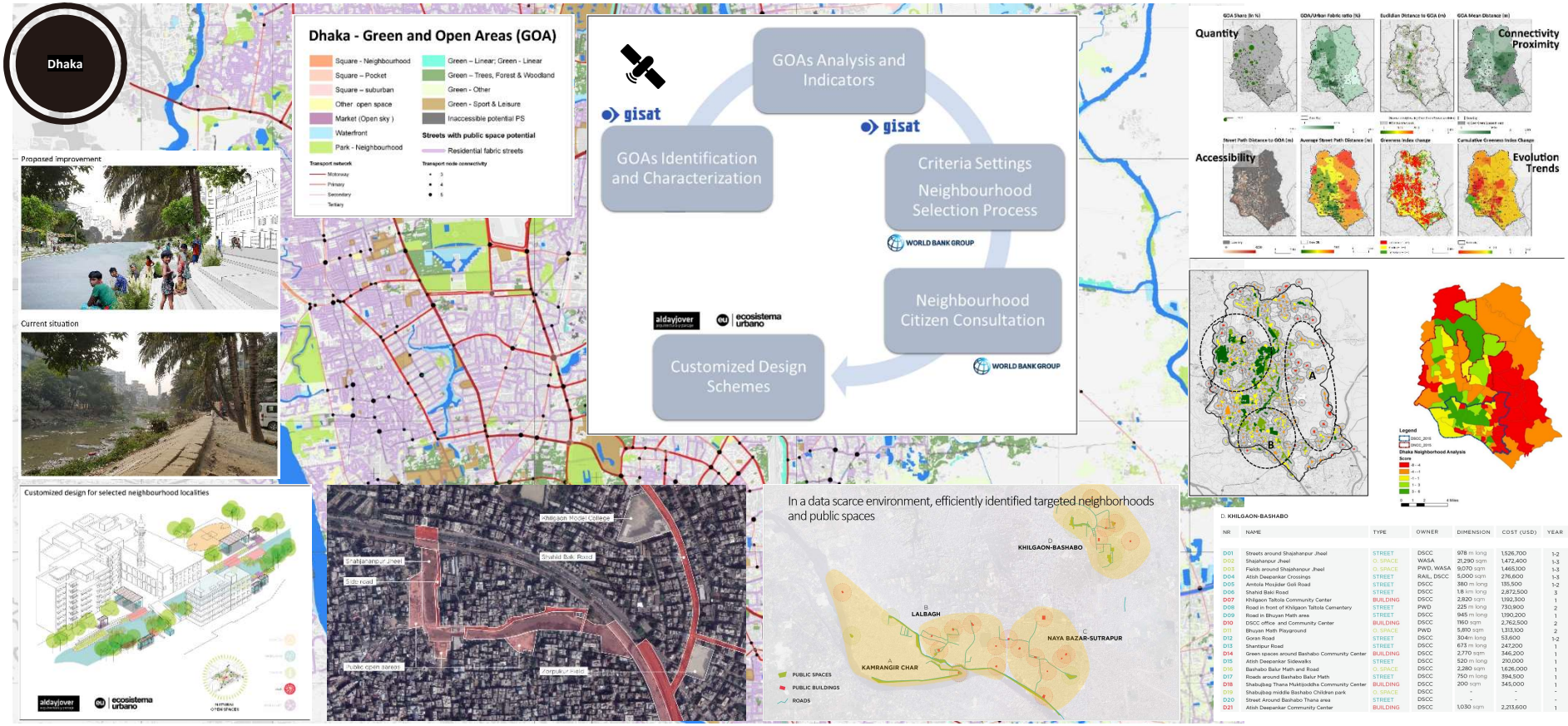
In order to better understand multi-faceted characteristics of public spaces, a rule-based typology has been developed and applied in case cities





Public Space – Green and Open Areas

EO Part of the Full Planning Cycle

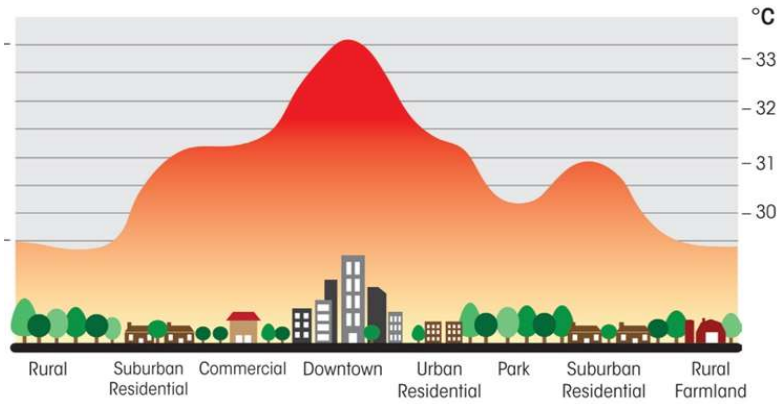


Heat Intensity / Heat Stress

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



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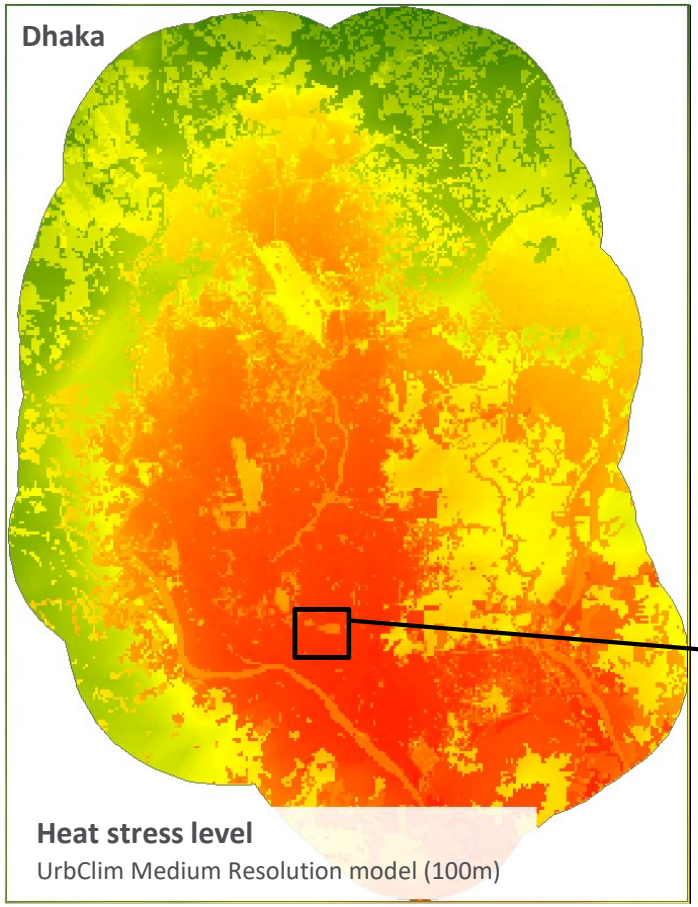
Heat Intensity / Heat Stress

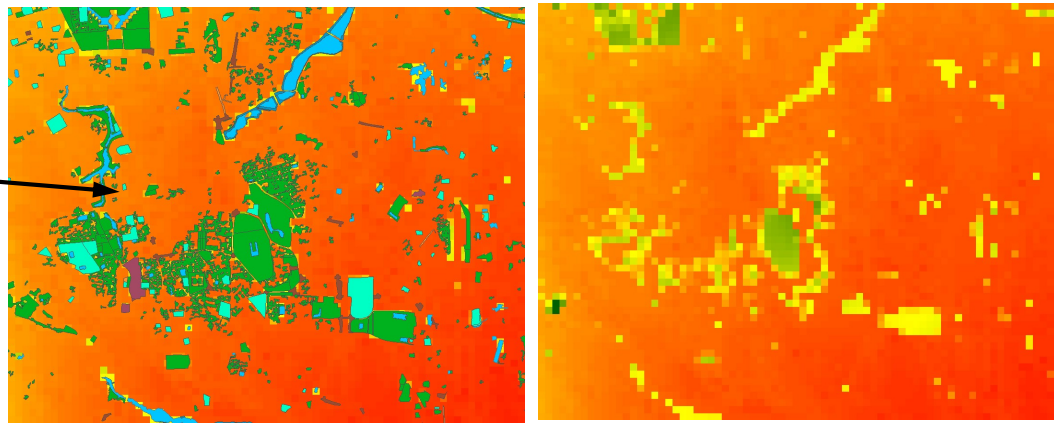
City-level planning, hot-spots, long-term development strategies



Urban Heat Island (UHI) intensity

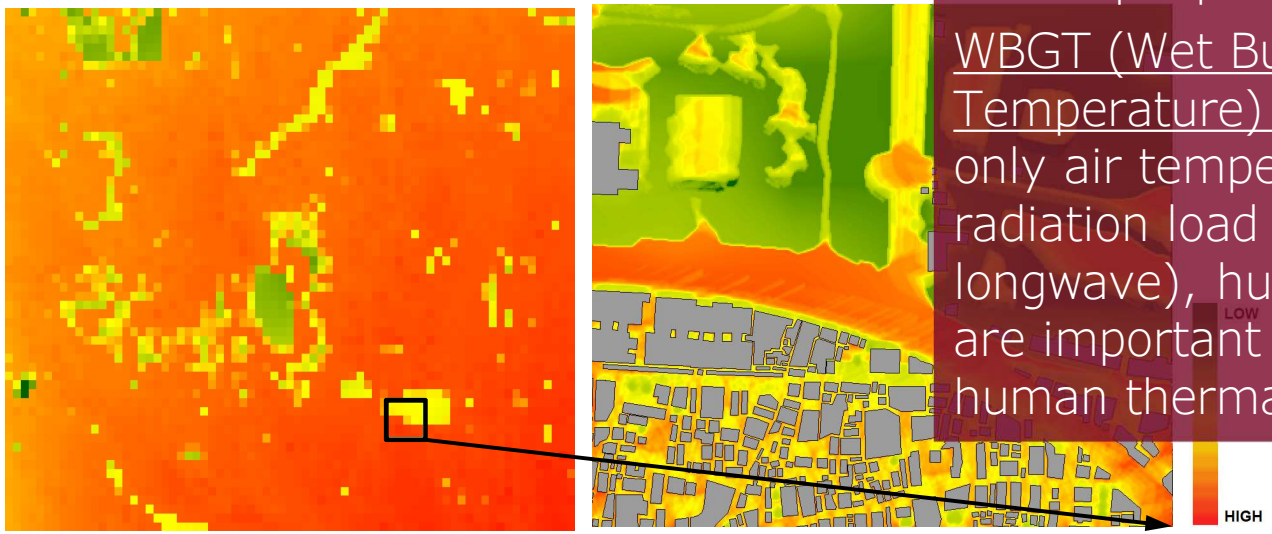
Average difference in 2m air temperature comparing to coldest location in the model domain at the moment of maximum urban heat island intensity

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

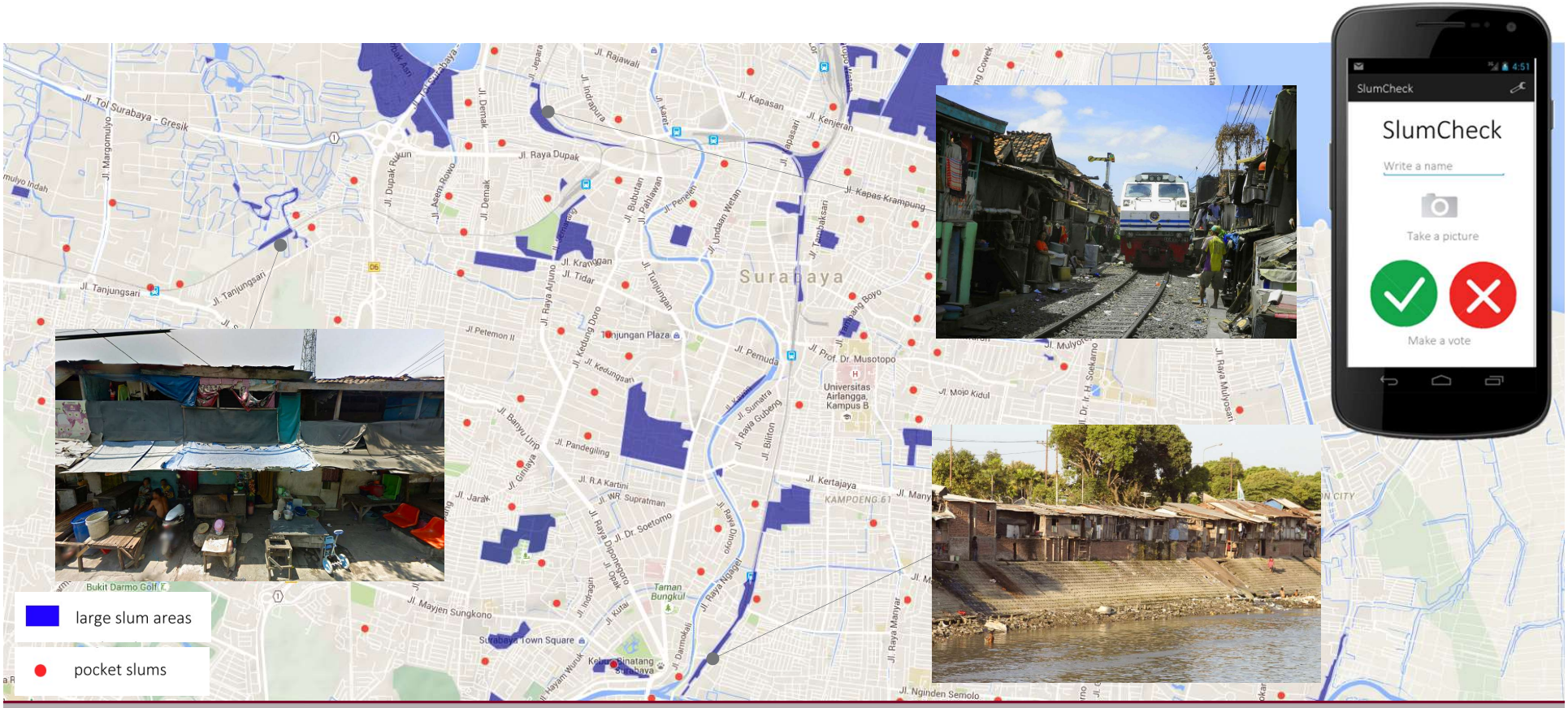
Different distribution of new buildings, trees (crown size, height) and paved or unpaved surfaces

Informal Settlements / Slums

Potential slums detection and delineation

Informal Settlements / Slums

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



Informal Settlements / Slums

Slum area characterization - slum areas typology

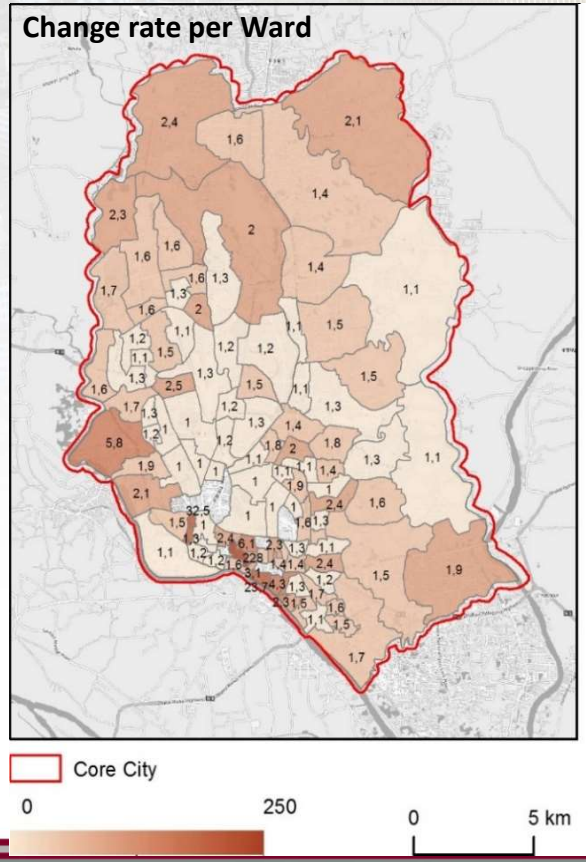
Name:	Tambak 02
Location:	Tanjungsari
City:	Surabaya
Type:	AlongRailway
Area:	2ha
Perimeter:	600m
Shape compactness:	Medium
Built-up density:	High
Built-up homogeneity:	Medium
Open spaces density:	Low
Greenness:	Low
Avg dwelling size:	50m2
Roof heterogeneity:	Low
Distance to paved road:	0.01km
Distance to railroad:	0.01km
Distance to centre:	6.3km
Distance to shoreline:	5.7km
Avg terrain slope:	5deg
Inundation risk:	Low
Landslide risk:	Medium

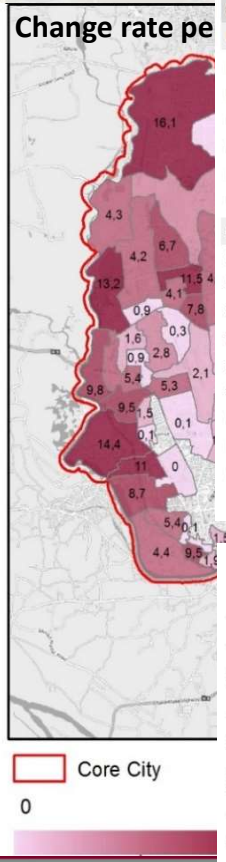
Informal Settlements / Slums

Slum development monitoring - change detection

Informal Settlements / Slums

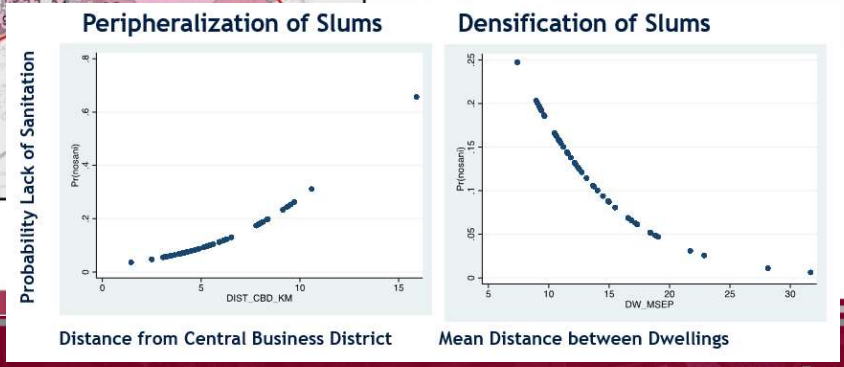
Service deprivation modelling. Beside slums identification, delineation and change monitoring, thorough characterization was done. Statistical model was trained by WASH data. Service Deprivation estimates extrapolated.





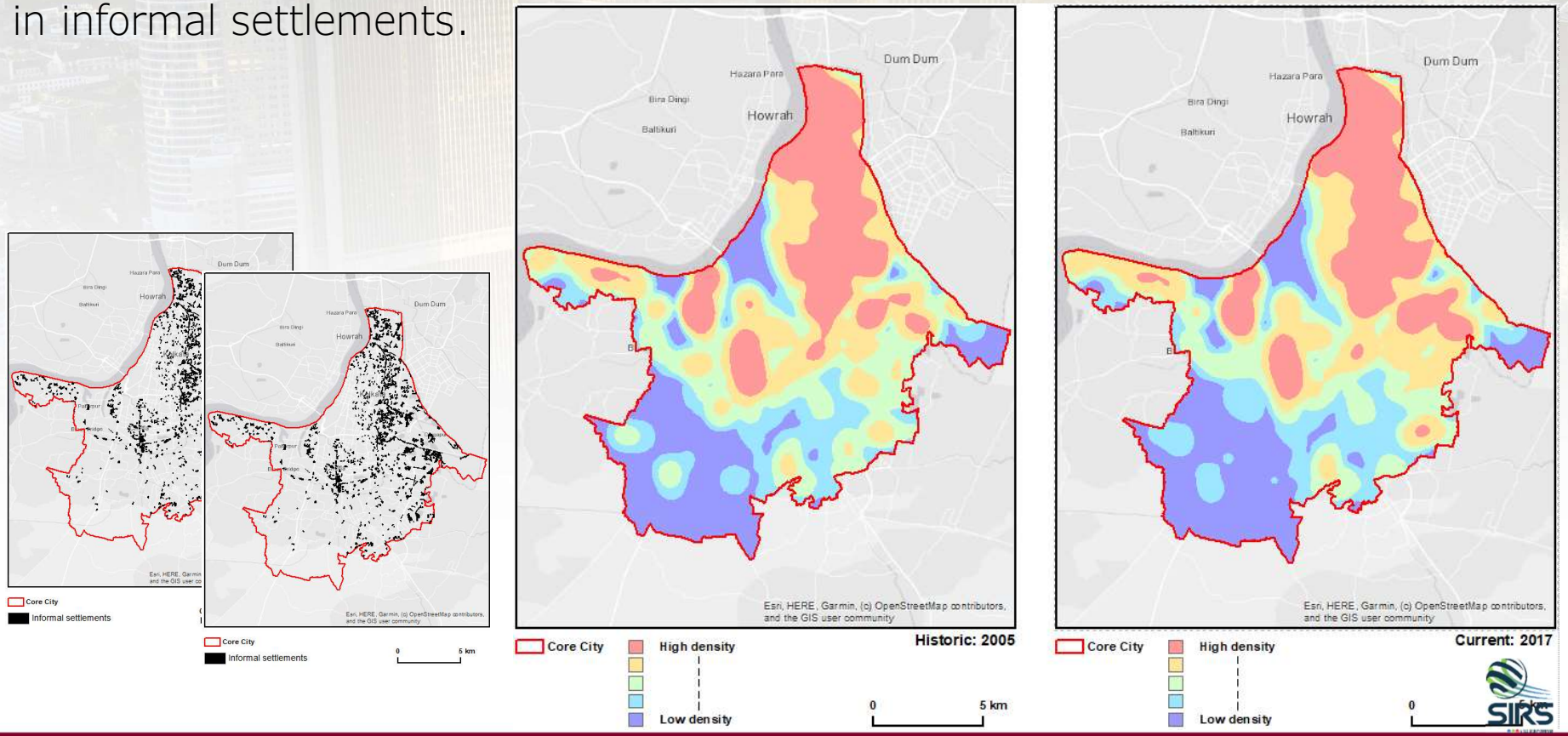
Indicator Group / Indicator	Indicator type	Input Data
Neighbourhood locational		
Distance to paved road	Quantitative	OSM, LULC
Distance to railroad	Quantitative	OSM, LULC
Distance to centre/CBD	Quantitative	LULC
Distance to nearest important connectivity node	Quantitative	OSM, LULC
Distance to (heavy) 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



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.

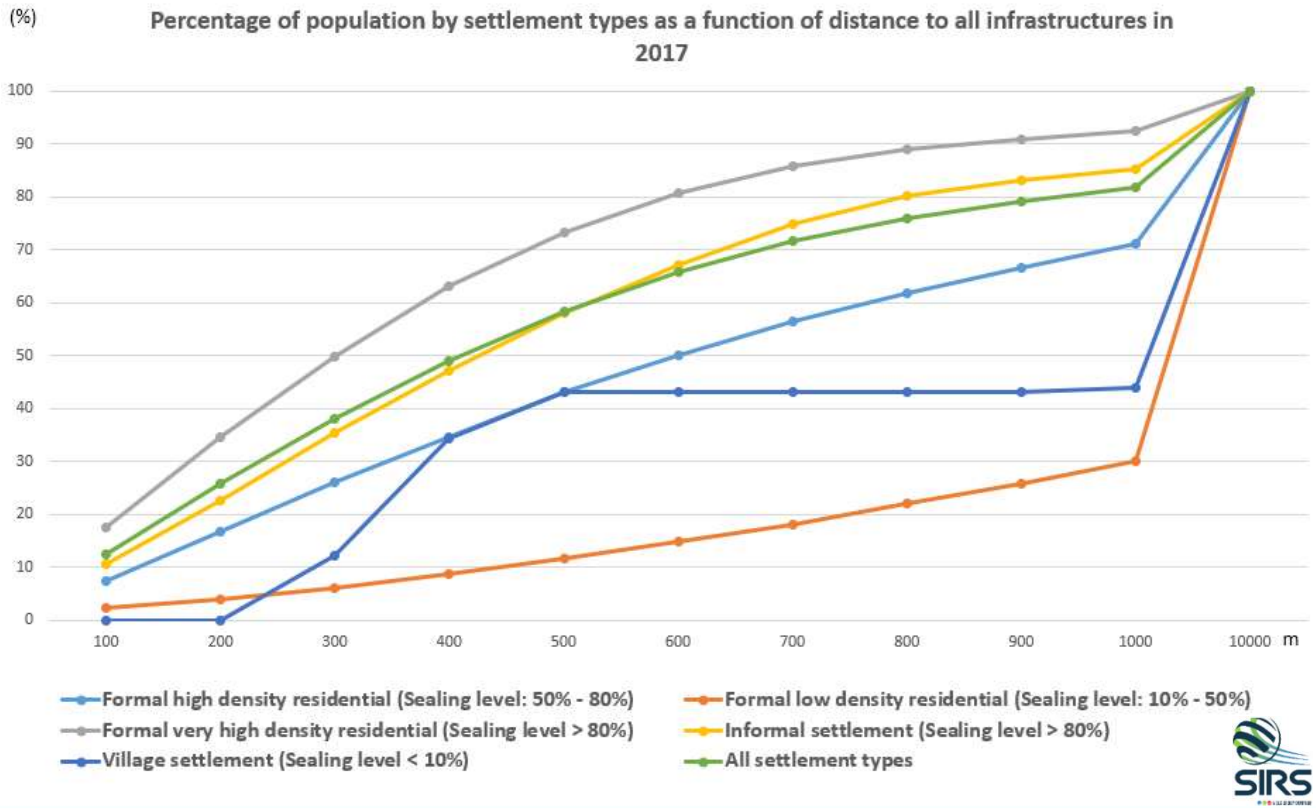


Informal Settlements / Slums

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.

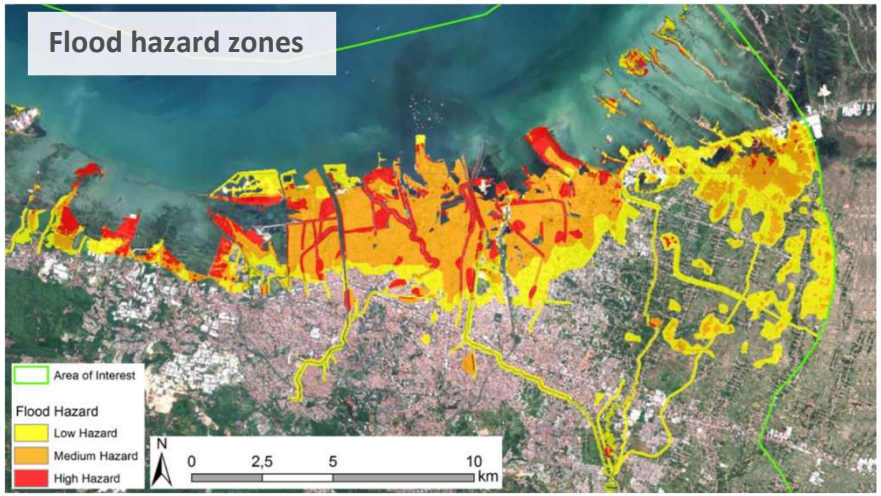
In Kolkata, the proximity of the slum population to infrastructure is comparable to that of the formal high and very high density residential.

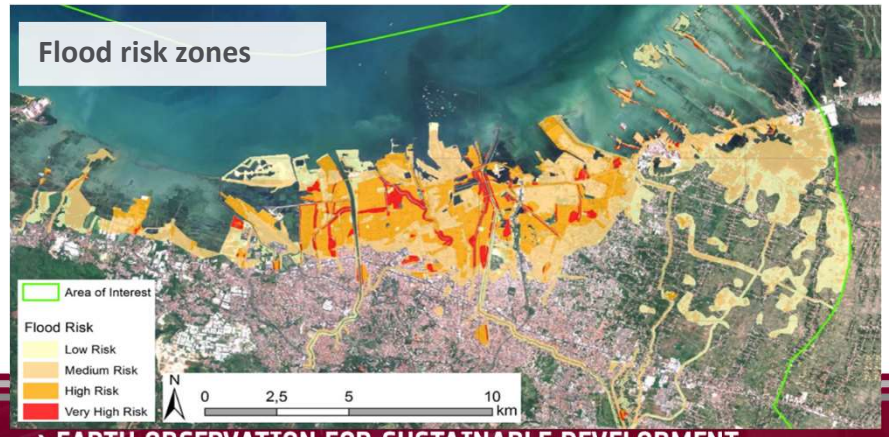
These trends are stable over time.

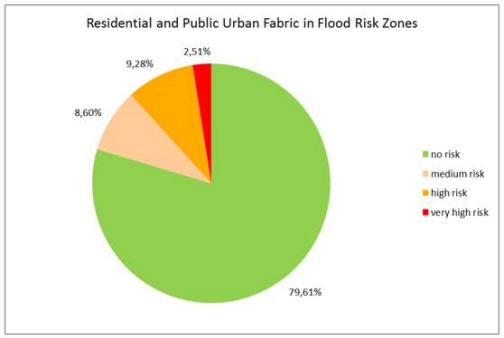


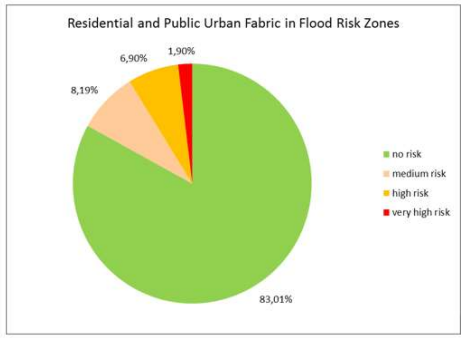
Risk Assessment

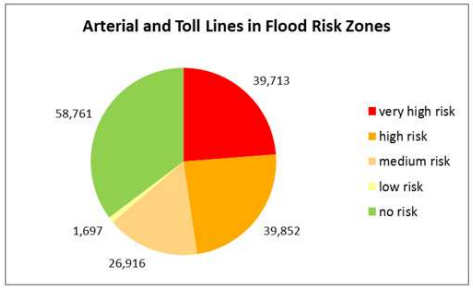
Multiple hazards which put in danger the City assets, some of them boosted by Climate Change (flood, subsidence, earthquake, landslides)

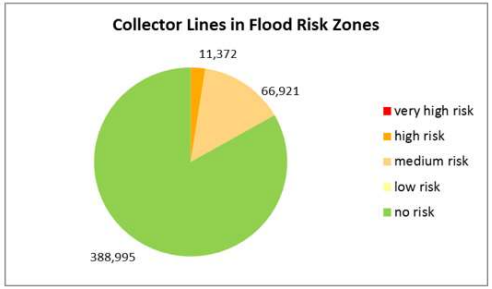








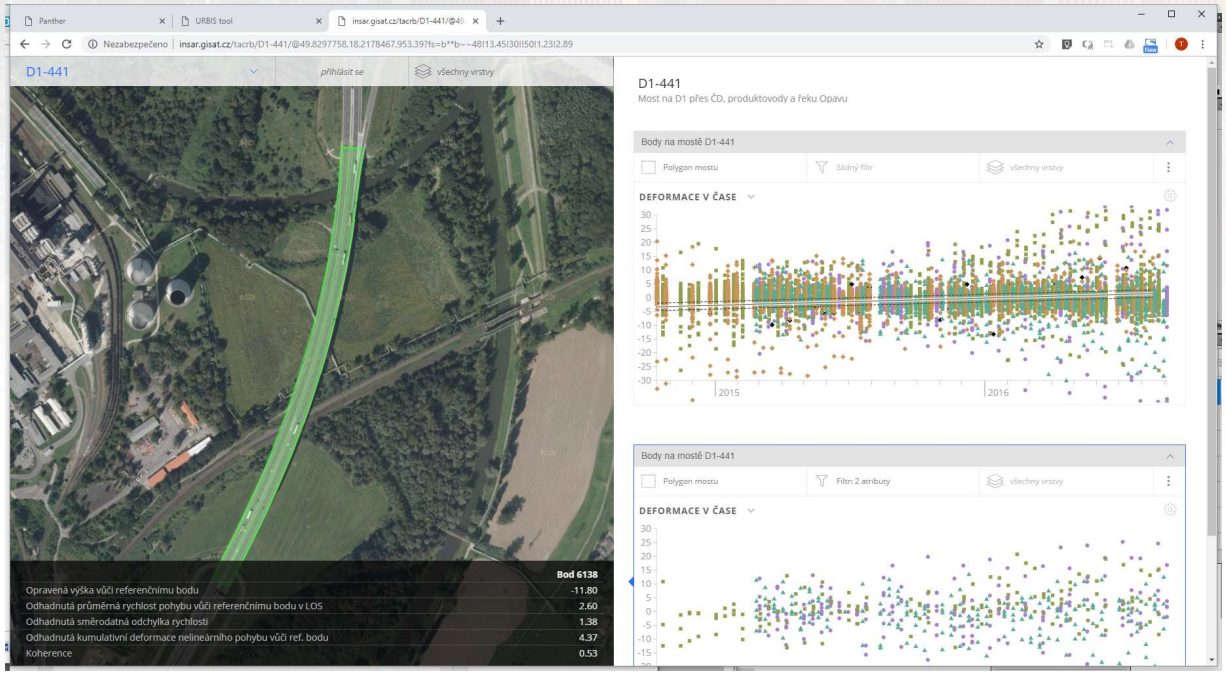


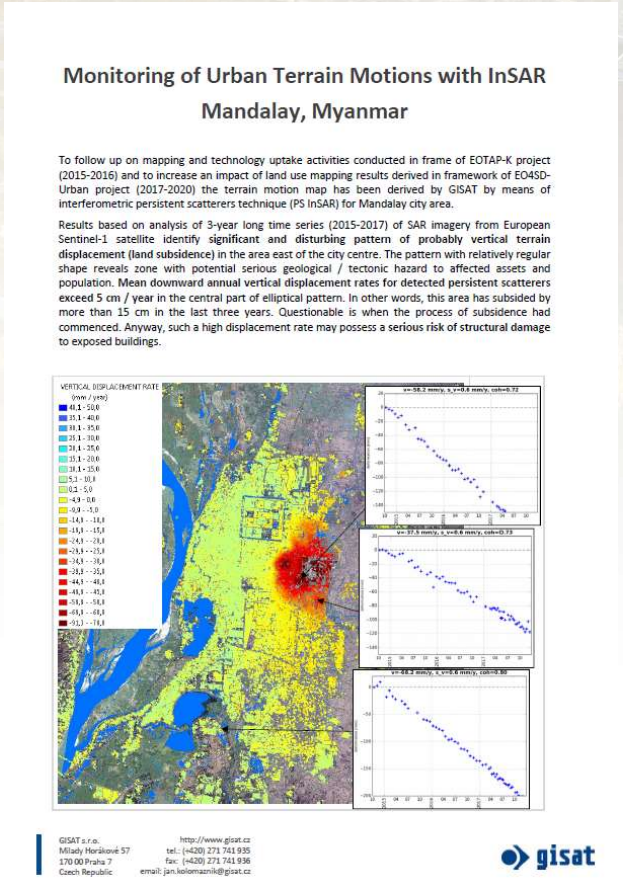


Example from Semarang for flood risk. Hazard and risk zone and base statistics of the City assets affected.

Risk Assessment

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





Conclusion

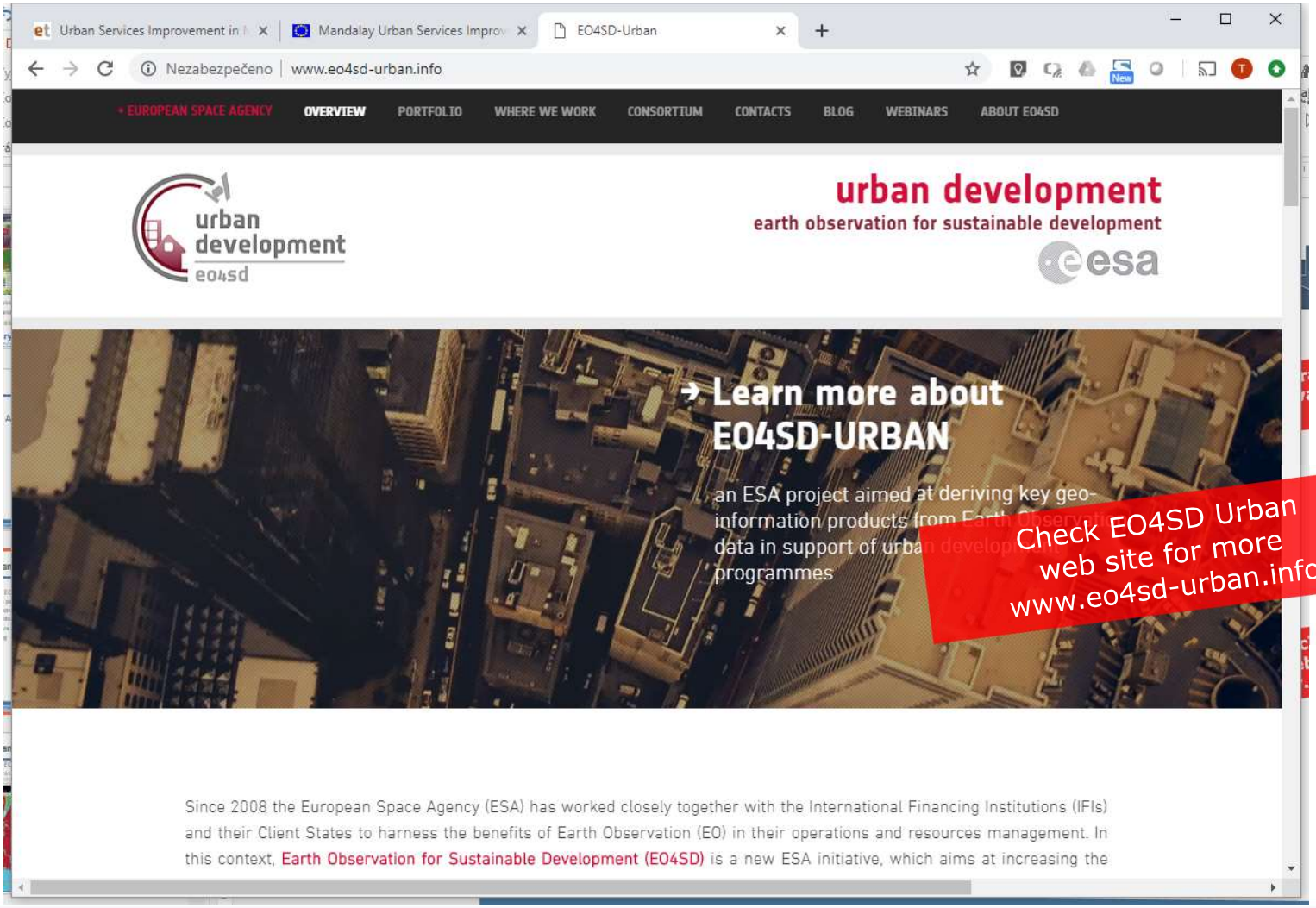
EO4SD-Urban: Value of the EO Products

EO4SD Urban EO-products are based on:

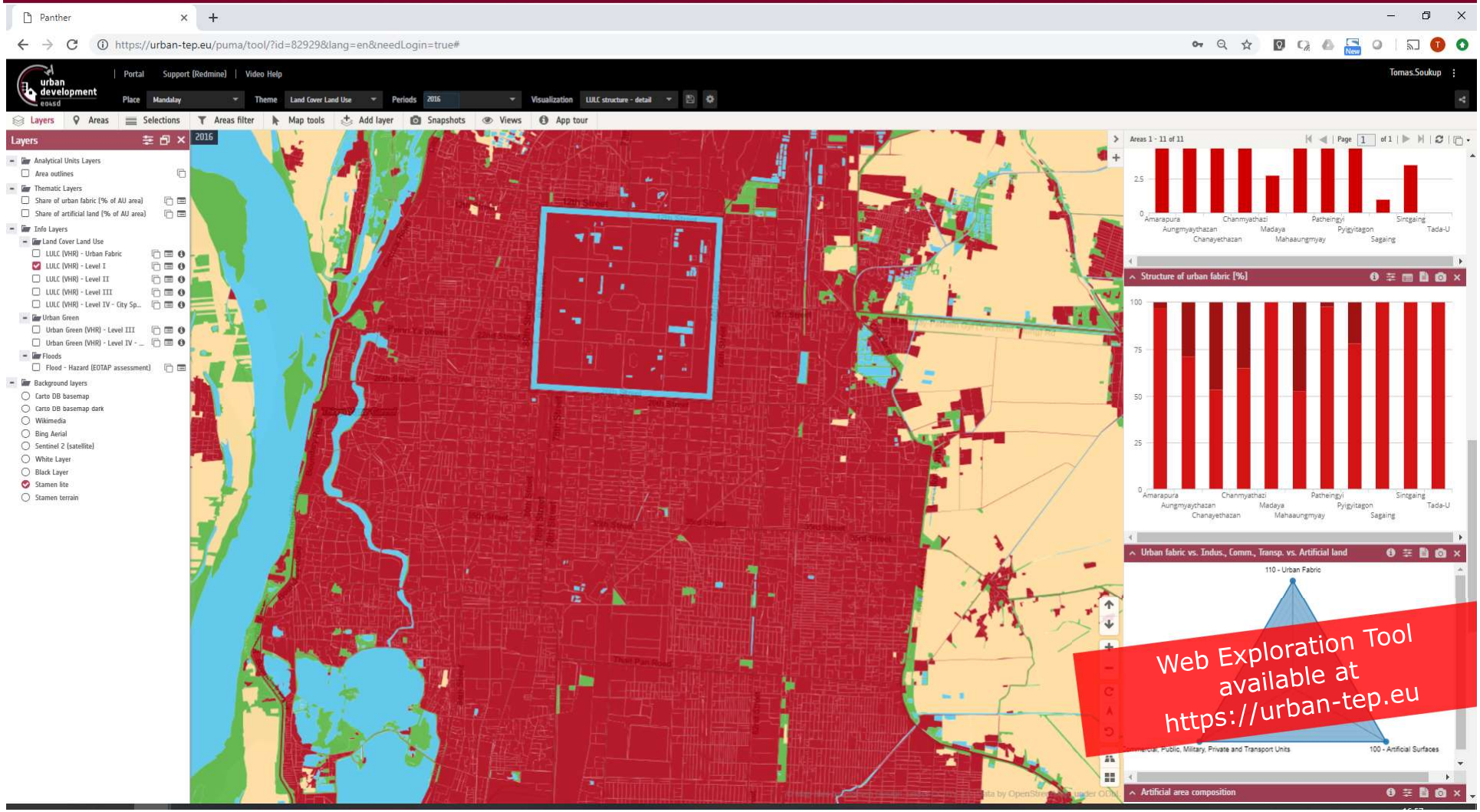
- Verified user requirements
- Harmonised and standardised state-of-the-art methodologies
- Comprehensive and transparent documentation
- Application of statistically sound accuracy assessment
- Stringent Quality Control to ensure:
  - transparency
  - repeatability
  - completeness
  - validity
- User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

More Resources

More Resources



More Resources



Thank you for your attention!

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