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
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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
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
ESA-DEVELOPED EARTH OBSERVATION MISSIONS

SENTINELS FREE AND OPEN ACCESS

European Contribution
European Contribution

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

Evidence-based planning with reliable and trackable data

GOVERNANCE
- Policies & regulations
- Zoning & FARs
- Risks

PUBLIC LIFE/PEOPLE
- Culture
- Health
- Safety
- Recreation
- Livelihoods
- Mobility
- Inclusion

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

MACRO
- Economy
- Population growth
- Real estate cycle
- Space demand

ACTORS
- Planners
- Local Govt.
- Investors
- Developers
- Communities
- Users

Evidence-based planning with reliable and trackable data

Knowledge needs are complex

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ACTORS
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Reality is often simple

Lack of Data
Lack of Resources
Luck 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.
### Potential for EO support is high

<table>
<thead>
<tr>
<th>Physical accessibility to cities</th>
<th>Urban assets-related Data Availability</th>
<th>Existence of a comprehensive land inventory</th>
<th>Potential for EO support</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>Smart Cities</td>
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<tr>
<td>✔️</td>
<td>✔️</td>
<td>✖️</td>
<td>Middle/high-income cities</td>
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<td>✔️</td>
<td>✖️</td>
<td>✖️</td>
<td>Most of WB Client Cities</td>
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<tr>
<td>✖️</td>
<td>✖️</td>
<td>✖️</td>
<td>FCV Cities</td>
</tr>
</tbody>
</table>

**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

More information available at [www.eo4sd-urban.info](http://www.eo4sd-urban.info)
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?
• 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)
• Amount and distribution of built-up area

- Lima 2015
- Bamako 2015
- Fallujah 2015
- Ramadi 2015

- Pie charts showing settlement area for each location:
  - Lima: 61.7%
  - Bamako: 67.2%
  - Fallujah: 46.6%
  - Ramadi: 37.8%

- Bar charts showing settlement area in km²:
  - Lima: 185.23 km²
  - Bamako: 167.71 km²
  - Fallujah: 65.62 km²
  - Ramadi: 65.84 km²
• Amount and distribution of built-up area (sealing level)
• Changes in space and time, axes of development

Mandalay (Myanmar)

Contact: mattia.marconcini@dlr.de
• 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
World Settlement Footprint (WSF) Evolution 1985-2015

Legend

Reference years

1985  1990  2000  2010


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

Contact: mattia.marconcini@dlr.de
Urban Growth Patterns in Arusha City (2000 – 2015)

- Pronounced Scattering
- Linear Strip Developments
- Leapfrog Islands
- Leapfrog Growth
- Edge and Infill Growth
Densification and compaction around the inner part of the city

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 unused land in-between

The process of suburbanization is guided by the reachability of regions.

Bhopal: Urban Growth between 1990 – 2015


European Space Agency
Vijayawada: Urban Growth between 1990 – 2015

Mainly densification and compaction around the inner part of the city.

Extensive infill growth.

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

Urban Extent (and Change)

Global products

Global Urban Growth Dynamics Monitoring

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

The urban land is a preponderant factor of global climate regulation. Understanding urban dynamics is therefore crucial, as urban expansion needs to be monitored to ensure its impact on climate is sustainable and does not impair the welfare of future generations. Moreover, the quality of life and safety of the urban population. The Copernicus urban products are available for urban studies to be done in rich spatial-temporal context, quickly and accurately.

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
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?
• 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
(Peri-) Urban Land Cover / Land Use
Regional and Detailed Products

Time series – ideally in line with planning cycles

EU Copernicus Land – Urban Atlas service heritage
https://land.copernicus.eu/local/urban-atlas
### Land Cover Land Use Nomenclature (LCLU)

<table>
<thead>
<tr>
<th>LULC Level I</th>
<th>LULC Level II</th>
<th>LULC Level III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial surfaces</td>
<td>Urban Fabric</td>
<td>Continuous Urban Fabric (Sealing Layer $SL &gt; 80%$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discontinuous Dense Urban Fabric ($SL \geq 50% - 80%$)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Discontinuous Low Density Urban Fabric ($SL \leq 10% - 50%$)</td>
</tr>
<tr>
<td>Industrial, commercial, public, military, private and transport unit</td>
<td>Industrial and commercial units</td>
<td></td>
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<tr>
<td></td>
<td>Non-residential urban fabric</td>
<td></td>
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<tr>
<td>Construction and other sites</td>
<td>Construction sites</td>
<td></td>
</tr>
<tr>
<td>Urban greenery</td>
<td>Urban green</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sport and leisure facilities</td>
<td></td>
</tr>
<tr>
<td>Non-artificial surface</td>
<td>Agriculture land</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Forest</td>
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<tr>
<td></td>
<td>Natural and semi-natural land including wetlands</td>
<td></td>
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<tr>
<td></td>
<td>Bare land</td>
<td></td>
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<tr>
<td></td>
<td>Water bodies</td>
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</tr>
</tbody>
</table>

**EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT**

**Urban development**
Regional and Detailed Products

Standard definition of flows

<table>
<thead>
<tr>
<th>LCF level 1</th>
<th>LCF level 2</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCF13: Urban extension: extension of transportation units</td>
<td>LCF13: Urban extension: extension of transportation units</td>
<td>Formation of new transportation units over non-artificial land</td>
</tr>
<tr>
<td>LCF15: Urban extension: extension of urban greenery</td>
<td>LCF15: Urban extension: extension of urban greenery</td>
<td>Formation of new urban greenery areas over non-artificial land</td>
</tr>
<tr>
<td>LCF16: Urban extension: extension of construction sites</td>
<td>LCF16: Urban extension: extension of construction sites</td>
<td>Formation of new construction sites over non-artificial land</td>
</tr>
<tr>
<td>LCF21: Urban internal changes</td>
<td>LCF22: Urban internal changes: formation and densification of residential urban fabric</td>
<td>Internal conversion between artificial surfaces, formation and densification of residential urban fabric over non-artificial land classes</td>
</tr>
<tr>
<td>LCF23: Urban internal changes: formation of commercial &amp; industrial units</td>
<td>LCF23: Urban internal changes: formation of commercial &amp; industrial units</td>
<td>Internal conversion between artificial surfaces, formation of commercial &amp; industrial units over non-artificial land classes</td>
</tr>
<tr>
<td>LCF25: Urban internal changes: formation of urban greenery</td>
<td>LCF25: Urban internal changes: formation of urban greenery</td>
<td>Internal conversion between artificial surfaces, formation of urban greenery over non-artificial land classes</td>
</tr>
<tr>
<td>LCF26: Urban internal changes: formation of construction sites</td>
<td>LCF26: Urban internal changes: formation of construction sites</td>
<td>Internal conversion between artificial surfaces, formation of construction sites over non-artificial land classes</td>
</tr>
<tr>
<td>LCF31: Agriculture uptake</td>
<td>LCF31: Agriculture uptake</td>
<td>Conversion of various types of natural and semi-natural land into agricultural land</td>
</tr>
<tr>
<td>LCF32: Agriculture abandonment</td>
<td>LCF32: Agriculture abandonment</td>
<td>Abandonment of agricultural land in favor of various types of natural and semi-natural land</td>
</tr>
<tr>
<td>LCF33: Agriculture development: consumption of urban fabric</td>
<td>LCF33: Agriculture development: consumption of urban fabric</td>
<td>Conversion of various types of urban fabric into agricultural land</td>
</tr>
<tr>
<td>LCF40: Natural and semi-natural internal changes</td>
<td>LCF40: Natural and semi-natural areas internal changes</td>
<td>Internal conversion between various natural and semi-natural classes</td>
</tr>
<tr>
<td>LCF41: Riverbed and water bodies development</td>
<td>LCF41: Riverbed and water bodies development</td>
<td>Conversion of water body into agriculture (related mostly to riverbed development)</td>
</tr>
<tr>
<td>LCF42: Riverbed development: Extension of agriculture</td>
<td>LCF42: Riverbed development: Extension of agriculture</td>
<td>Conversion of agriculture into water body (related mostly to riverbed development)</td>
</tr>
<tr>
<td>LCF43: Riverbed development: extension of natural and semi-natural areas</td>
<td>LCF43: Riverbed development: extension of natural and semi-natural areas</td>
<td>Conversion of water body into natural and semi-natural land (related mostly to riverbed development)</td>
</tr>
</tbody>
</table>
(Peri-) Urban Land Cover / Land Use
Regional and Detailed Products

Statistics – understanding intensity and ‘cons / forms’ flows
Land Assets Statistics – comparison of trends - overall

(Mandala (Myanmar) - Land Cover Flows Analysis - Overall
2002-2014 vs 2014-2016

Legend:
100 - Artificial Surfaces
200 - Agricultural Area
300 - Natural and Semi-natural Area
400 - Wetlands
500 - Water
Land Assets Statistics – Trends in Urban Expansion

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

2002-2014 vs 2014-2016

LULC Data - Land Use - City Specific:
- 11100 - High density continuous residential urban fabric (Floor area ratio >10)
- 11200 - High density discontinuous residential urban fabric (Floor area ratio 5-10)
- 11300 - Low density discontinuous residential urban fabric (Floor area ratio <5)
- 12101 - Commercial units
- 12201 - Industrial units
- 12301 - Education
- 12401 - Healthcare
- 12501 - Military
- 12502 - Religious
- 12601 - Religious
- 12701 - Hospital
- 15101 - Airport
- 15201 - Construction sites
- 15300 - Land without current use
- 15401 - Parks
- 15501 - Water
- 15601 - Sport fields
- 15701 - Residential
- 15801 - Cemetery
- 20000 - Agricultural land
- 21000 - Permanent cultivation
- 22000 - Pastures
- 23000 - Other natural and semi natural areas including wetlands
- 24000 - Built land
- 31000 - Inland water
Land Assets Statistics – Trends in Urban Densification

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

2002-2014

2014-2016

(Peri-) Urban Land Cover / Land Use
Regional and Detailed Products
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

Comparative Analysis with existing Master Plan

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

- Urban parks
- Residential
- Institutional
- Industrial
- Forest and shrubs
- Commercial
- Arterial and collector roads
- Agriculture

Legend:
- Residential, 0-10%
- Residential, 10%-30%
- Residential, 30%-50%
- Residential, 50%-80%
- Residential, 80%-100%
- Forest, shrublands, woodlands and other natural areas
- Urban parks and recreational
- Commercial and CBD
- Industrial, construction site, mining quarrying, dumpsites
- Arterial and collector roads and railway
- Airport and port
- Bare soil
- Land without current use

Planned vs Unplanned Settlements

Arusha City

2000 - 2015

- 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

2000 - 2015

- 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.
City Land Assets Structure and Evolution

Earth Observation data can provide insights 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 can influence city sustainability and resilience, as well as determine physical amenities, opportunities, and potential for further development.

Saint Louis

The graphs above provide an overview of LULC structure (class of urban areas) in Saint Louis for a given reference year. Note: Losing or gain of land areas are not complete city coverage.

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 - 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

Building Information
- Area of Interest
- Building Unchanged (2009/2014)
- Building New (2014)
- Building Demolished (2014)
- Building Footprint

Digital Terrain Model with 3D Building Footprints

EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT
Urban development
Building Footprints
Very Detailed Local Product

Structural indicators on individual buildings level

Distance
Roof Material

Building Information
Area of Interest
Building Unchanged (2009/2014)
Building New (2014)
Building Demolished (2014)

EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT
Urban development
• **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
LULC, Census Data and VHR DSM for urban blocks
LULC, Census Data and VHR DSM for urban blocks
Population Density
Local Product

LULC, Census Data and VHR DSM for urban blocks

Mandalay
Population census disaggregation

Population Density
Local Product

Mandalay
A street density (road surface / total area) gives a quick understanding about the typology of the City.
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.
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 km² 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.

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.
Green Areas

Mapping and monitoring of urban green areas

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

The EO4SD Urban program provides a range of tailored products designed for the monitoring and analysis of urban green areas. These products allow for the assessment of the state and development of urban green areas at a local level, thus providing evidence-based information that can support urban planning and policy-making.

Abidjan

Distribution of artificial green areas (consisting of two classes) in the current year is presented in the map format. Past the city from top left corner to display the map for respective city. Distribution is shown in the green area (in green) and changes between the two baselines are shown in a green area (in green). This information can be used to identify patterns of green area development and the impact of urbanisation on green areas.

Urban Green Areas

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

<table>
<thead>
<tr>
<th>Indicator group</th>
<th>Indicator</th>
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</thead>
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<td>Distance and accessibility</td>
<td>Distance to roads, amenities</td>
</tr>
<tr>
<td>Patterns</td>
<td>Distance to water</td>
</tr>
<tr>
<td>Distance to nearest Road?</td>
<td>Shape linearity, size, compactness</td>
</tr>
<tr>
<td>C2. Adjacent to Water</td>
<td>Vegetation typology (high, low, bare)</td>
</tr>
<tr>
<td>C3. Compactness: Linear or not</td>
<td>Park probability indicator</td>
</tr>
<tr>
<td>C4. Patterns</td>
<td>LULC patterns and proportions</td>
</tr>
<tr>
<td>C5. Location (Urban Mask)</td>
<td>Built-up proportions and adjacency</td>
</tr>
<tr>
<td>C6. Size</td>
<td>LULC adjacency</td>
</tr>
</tbody>
</table>

- C1. Distance to nearest Road?
- C2. Adjacent to Water
- C3. Compactness: Linear or not
- C4. Patterns
- C5. Location (Urban Mask)
- C6. Size
In order to better understand multi-faceted characteristics of public spaces, a rule-based typology has been developed and applied in case cities.
Dhaka – Green and Open Areas (GDA)

GOAs Analysis and Indicators

GOAs Identification and Characterization

Criteria Settings

Neighbourhood Selection Process

Neighbourhood Citizen Consultation

Customized Design Schemes

In a data scarce environment, efficiently identified targeted neighborhoods and public spaces.

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
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
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.
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

**Slum Areas Typology**

Residential Center
Suburban Industrial
Urban Fringes
Along Railway
Along Roads
Along Shore
Pocket Slums

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.
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 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.
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 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
Thank you for your attention!

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