Remote Sensing for Cities Support on the Ground
Analytics and Spatial Indicators: EO4SD-Urban Experience

Speaker

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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
• **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.
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 of Indicators or/and Analytics.
Understanding global urbanisation trends in last 30 years

Global WSF Evolution data freely available Q1/2020 via www.urban-tep.eu
Amount and distribution of built-up area
Sealing levels (aka level of imperviousness) distribution
Change dynamic axes / corridors of development
Understanding City potential and limitation regarding land assets

Mandalay (Myanmar) - Land Cover Flows Analysis - Overall
2002-2014

Mandalay (Myanmar) - Land Cover Flows Analysis - Urban Expansion
2002-2014

Mandalay (Myanmar) - Land Cover Flows Analysis - Urban Densification
2002-2014
Master Plan Reality Check

1985 Master Plan

2015 Actual Land Use

Diversion from proposed land use

Arusha, Tanzania

Strategic / Operational Level Support
Land Assets Management
Strategic / Operational Level Support
Land Assets Management

Master Plan Reality Check

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

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

Diversion from proposed land use

Operational Level Support
Building Footprint

Detailed information on building (blocks) level

Digital Terrain Model with 3D Building Footprints

Building Information
- Area of Interest
- Building Unchanged (2009/2014)
- Building New (2014)
- Building Demolished (2014)
- Building Footprint
Individual building or building block heights for large areas
Operational Level Support
Population Distribution / Density

LULC, Census Data and VHR DSM for urban blocks

Mandalay

EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT
Urban development
Operational Level Support
Population Distribution / Density

LULC, Census Data and VHR DSM for urban blocks

Mandalay

EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT
Urban development

European Space Agency
Operational Level Support
Population Distribution / Density

LULC, Census Data and VHR DSM for urban blocks
Spatially enhanced population data
A street density (road surface / total area) gives a quick understanding about the typology of the City.
Operational Level Support
Transport

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
**Operational Level Support**

**Urban 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*.

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, 2016; World Population review, 2019).
Identification, quantification and characterization of potential public urban spaces

Coherent with SDG 11.7 implementation (UN-HABITAT)
Step II: City-wide Assessment
Testing Analytics

Spatial Analysis describing public space network

- GOA Share (in %)
- GOA/Urban Fabric ratio (%)
- Euclidian Distance to GOA (m)
- GOA Mean Distance (m)
- Connectivity
- Proximity
- Walkability
- Slums
- Street Path Distance to GOA (m)
- Average Street Path Distance (m)
- Greeness Index change
- Cumulative Greeness Index Change
- Evolution Trends
- Inclusivity
- Flood risk

- EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT
  Urban development
EO supporting a full planning cycle

Dhaka - Green and Open Areas (GOA)

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.
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
Strategical / Operational Level Support
Heat Intensity

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
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 Index (WBGT Index), is a widely used indicator (ISO 7243:2017) for assessing 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

Slum Areas Typology

Residential Center
Suburban Industrial
Urban Fringes
Along Railway
Along Roads
Along Shore
Pocket Slums
Slum development monitoring - change detection
Multiple hazards which put in danger the City assets, some of them boosted by Climate Change (flood, subsidence, earthquake, landsides).

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 update activities conducted in frame of GEAR-4 project (2011-2016) and to increase an impact of land use mapping results designed in framework of GEAR-4 Urban project (2017-2020), the terrain motion map has been derived by ESAF by means of interferometric persistent scatterers technique (IsPSAR) for Mandalay city area.

Results based on analysis of 5-year long time series (2012-2017) of SAR imagery from European (Sentinel 1) satellite identify significant and dilating pattern of probable vertical subsidence (land subsidence) in the area east of the city centre. The pattern with relatively regular shapes reveals zone with potential severe groundwater / historic and affected assets and population. Values downward annual vertical displacement rates for detected persistent scatterers exceed 5 cm/year in the central part of affected area. In other words, the area has subsided by more than 25 cm in the last three years. Questionable is when the process of subsidence had commenced anyway, such a high displacement rate may pose a serious risk of structural damage to exposed buildings.

→ EARTH OBSERVATION FOR SUSTAINABLE DEVELOPMENT

Urban development

European Space Agency
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
Global Urban Growth Dynamics Monitoring

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

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

As the EO4SD-Urban project contribution to the 3rd Global GPSC Meeting available at
https://urban-tep.eu/visat/scudeoStories19/globalWsf
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 cities. Physical constraints, opportunities and potential for further development need to be determined.

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)

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

https://urban-tep.eu/visat/scudeoStories19/landAssetsStructure
Mapping and monitoring of urban green areas

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

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

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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