

**EU Research and Innovation in Support of the Earth
Observation Market**
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Brussels



Urban Sprawl in Latin American Metropolitan Areas (Bogota, Quito and Lima) – Derivation of socioeconomic data

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Monitoring Urbanization in Latin American Metropolitan Areas

... a project focusing on preparation of demonstration cases for Urban Mapping

within the context of



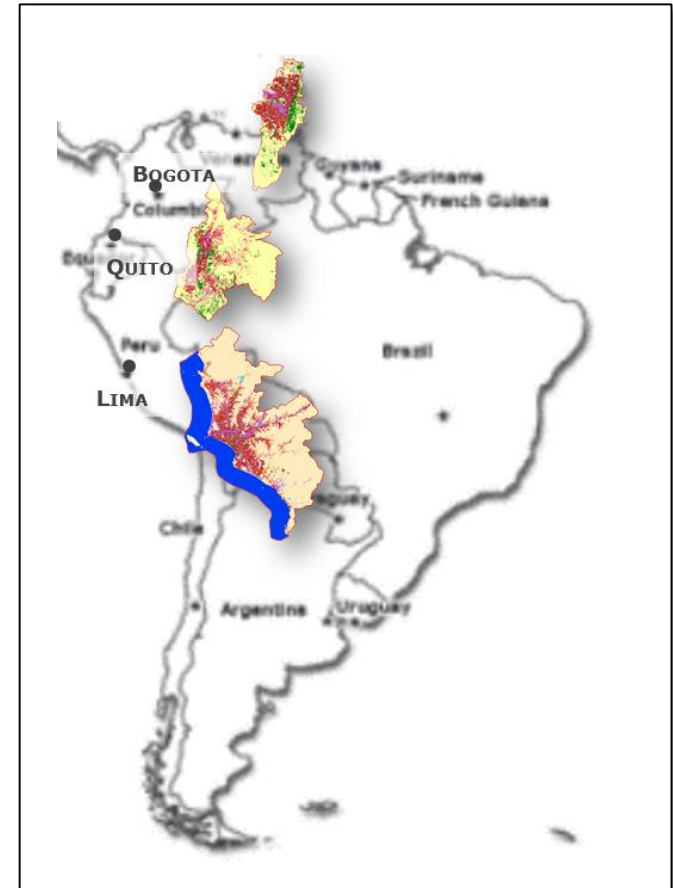
financed by ESA
(ESRIN/AO/1-7663/13/I-AM)



key users



Service design,
preparation & analysis

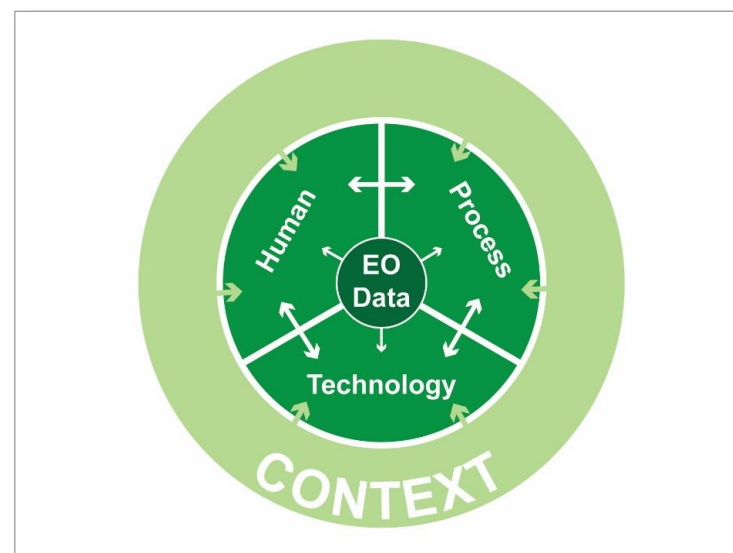
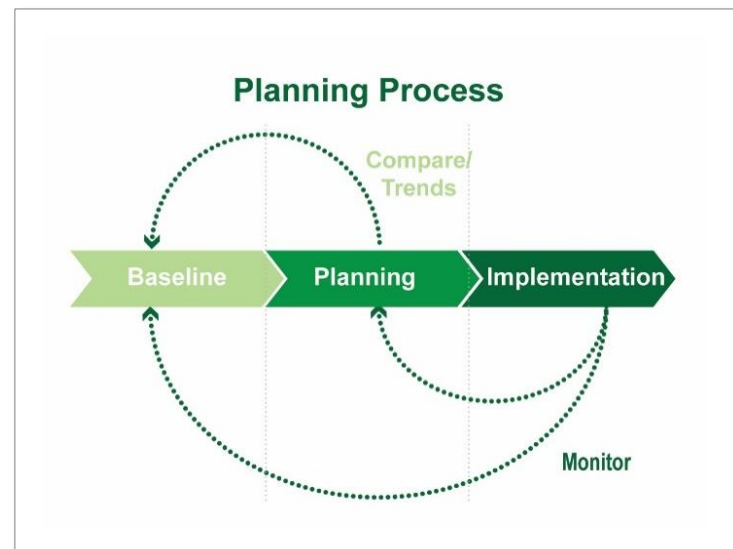


Background: The World Bank Project

Monitoring Urbanization in Latin American Metropolitan Areas

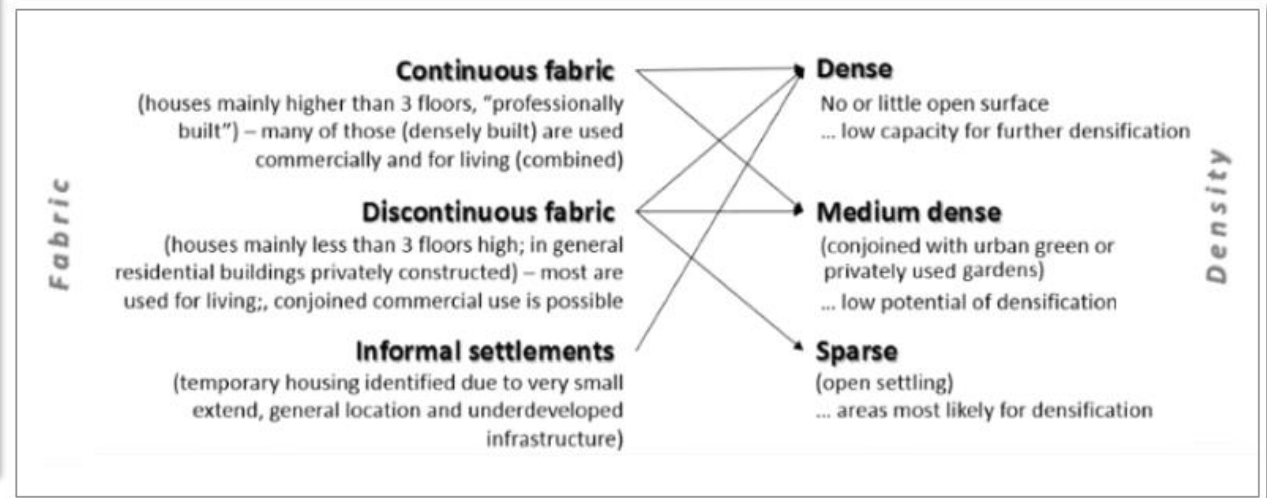
Main objectives:

- Development of a **time & cost efficient** process for urban structure analysis
- The **capability of Earth Observation** as suitable basis for baseline mapping, urban planning and monitoring
- Establish standard procedure to create **comparable results on a global level** (*Urban Atlas* classification)
- **Historical analysis** of urban sprawl in order to derive urban growth patterns.
- Detection of potential hotspots for **urban risks**
- **Derivation of socioeconomic data** for transportation planning





http://www.mtritter.org/travel/Bolivia_Paraguay_Uruguay/slides/DSC_3004.JPG



Advantages

- Different fabric often represent different characteristics of living/ use fragmentation
- Different density separates areas of similar fabric
- Identifying urban density is a fast & cost effective way of identifying mixed areas without footprint allocation
- Density of housing can be analysed according to its change over time
- Combination of Fabric + Density allows estimation of population (other input: known absolute numbers or spatial resolution of income or ...)
- It works all over the World

Limitation

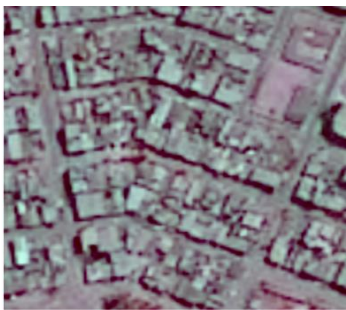
- Formal/ Informal structures relate to image texture (small features, often crowded)



**Continuous
dense urban fabric**



**Continuous
medium dense urban fabric**



**Discontinuous
dense urban fabric**



**Discontinuous
medium dense urban fabric**



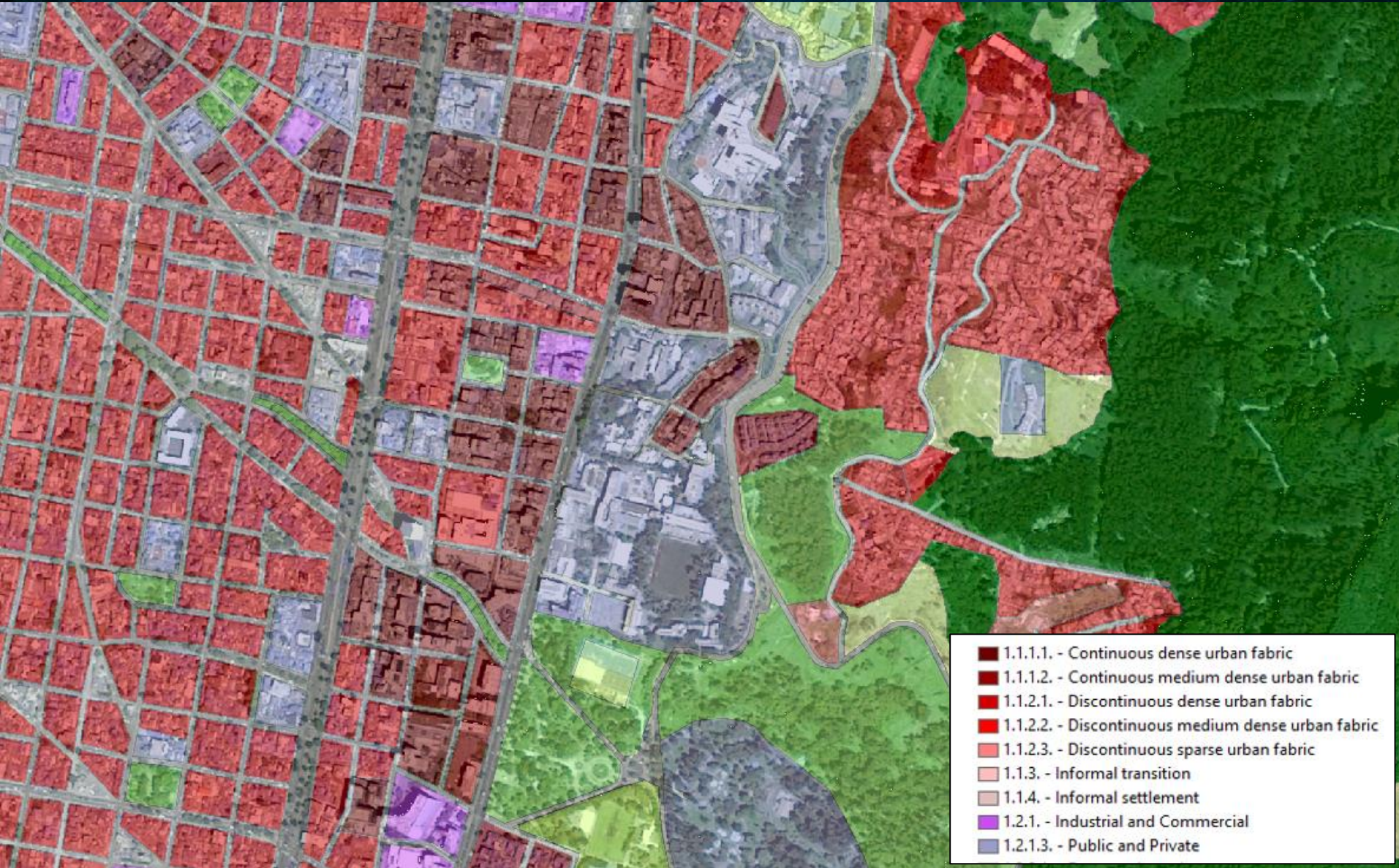
**Discontinuous
sparse urban fabric**



Informal settlement

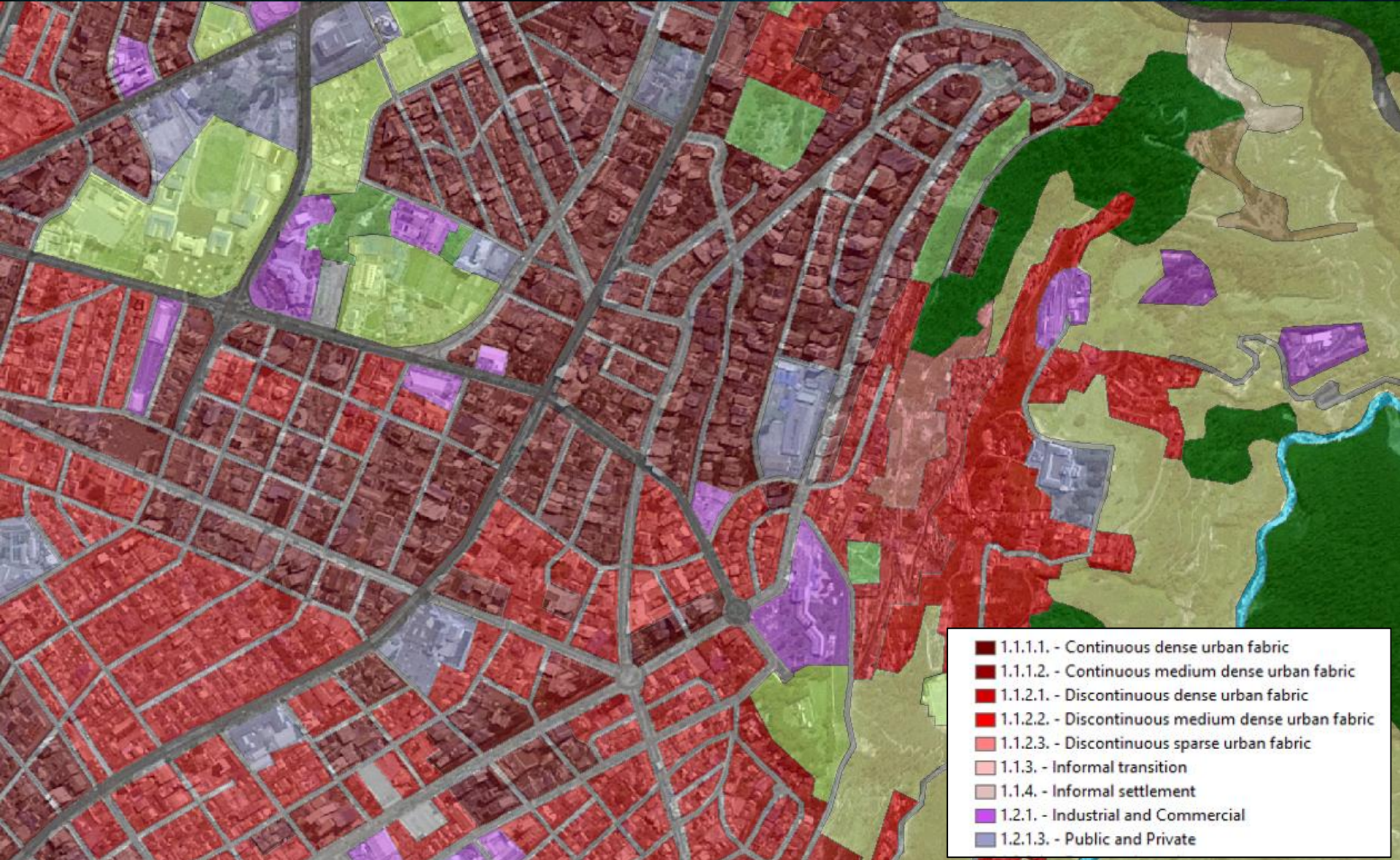
Urban Atlas - Logic of 6 different housing classes

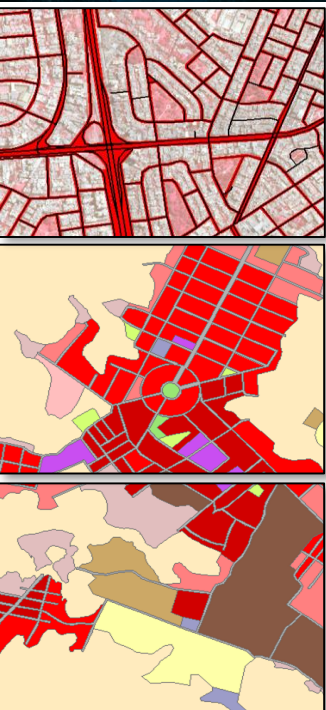
Bogota



Urban Atlas - Logic of 6 different housing classes

Quito



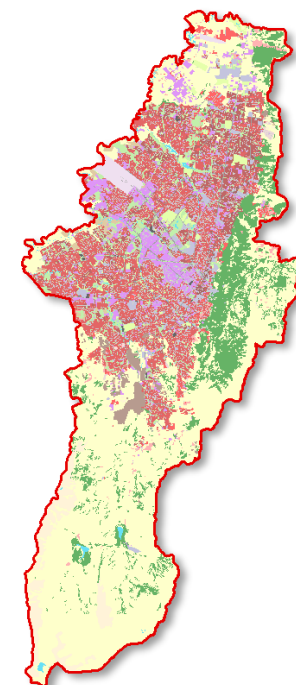


Transportation network 2013

- fast transit road, Other road; Railroad
- all roads wider 10m (buffering in 3m intervals)

Urban Service 2013 and 2000

- Urban Atlas Standard (minimum mapping unit 0,25/ 1ha)
- geometry compatible to Google Maps/ ESRI Basemap
- thematic accuracy > 96 %
... cities Lima, Quito & Bogota: 71,800 polygons
- Backdating approach:
(1) mapping 2013; (2) mapping 2000 (considering 2013)
- 18 urban classes, 5 other classes

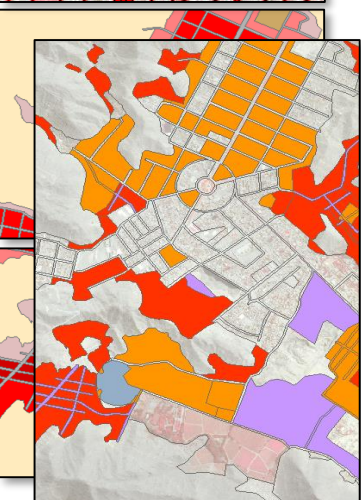


■ 1.1.1.1. - Continuous dense urban fabric	■ 1.2.2.1. - Fast transit road	■ 2.1. - Agriculture and natural vegetation
■ 1.1.1.2. - Continuous medium dense urban fabric	■ 1.2.2.2. - Other road	■ 2.2. - Bare ground
■ 1.1.2.1. - Discontinuous dense urban fabric	■ 1.2.2.3. - Railway	■ 3. - Forest
■ 1.1.2.2. - Discontinuous medium dense urban fabric	■ 1.2.3. - Port area	■ 5.1. - Inland water
■ 1.1.2.3. - Discontinuous sparse urban fabric	■ 1.2.4. - Airport	■ 5.2. - Marine water
■ 1.1.3. - Informal transition	■ 1.3.1. - Mineral extraction and dump site	
■ 1.1.4. - Informal settlement	■ 1.3.3. - Construction sites	
■ 1.2.1. - Industrial and Commercial	■ 1.4.1. - Green urban areas	
■ 1.2.1.3. - Public and Private	■ 1.4.2. - Sports and leisure facilities	



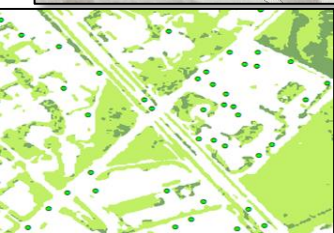
Transportation network 2013

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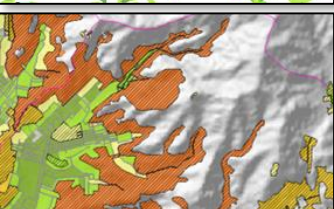
Urban Service 2013 and 2000

- Urban Atlas Standard
(minimum mapping unit 0,25/ 1ha)
- ⇒ **Urban Change Layer**
- detailed change types
 - grouped into main change characteristics



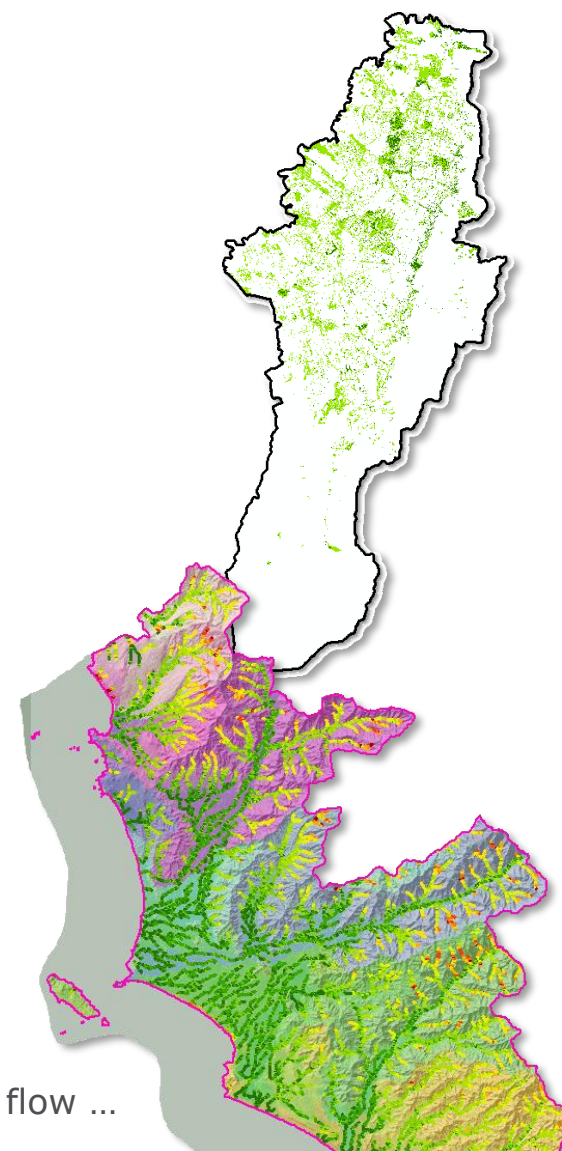
Urban Vegetation Layer 2013

- low and high vegetation
- minimum mapping unit 0,1ha
- significant single trees

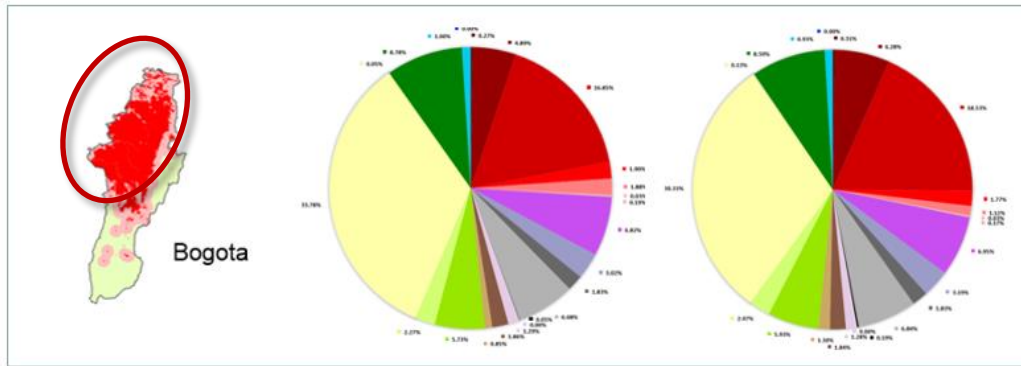


Terrain Analysis

- considering Urban Mapping Service(s)
- Risk identification, calculation of natural drainage flow ...

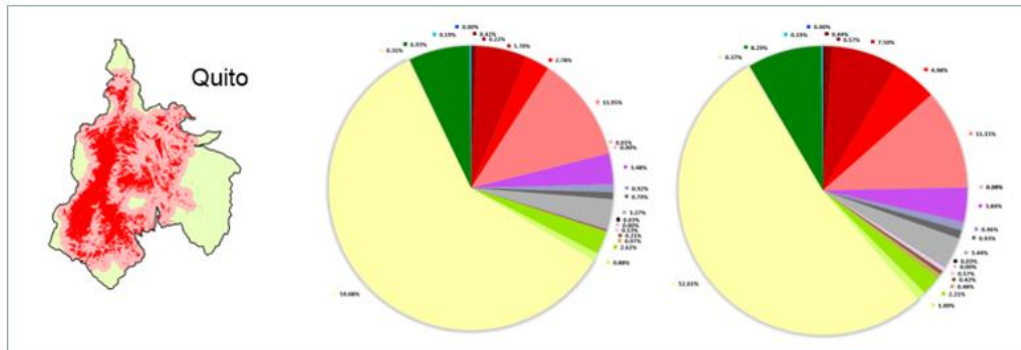


Comparability of Metropolitan regions



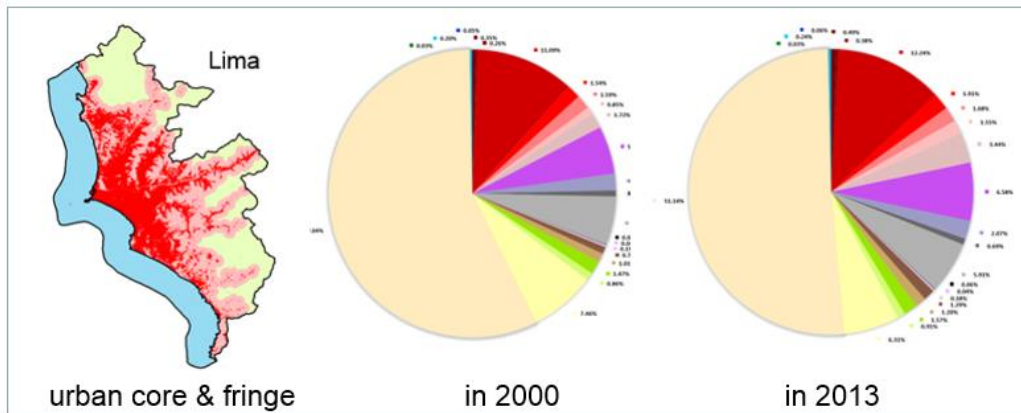
Urban Atlas

- 1.1.1.1 - Continuous dense urban fabric
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- 3 - Forest
- 5.1 - Inland water
- 5.2 - Marine water



comparable due to

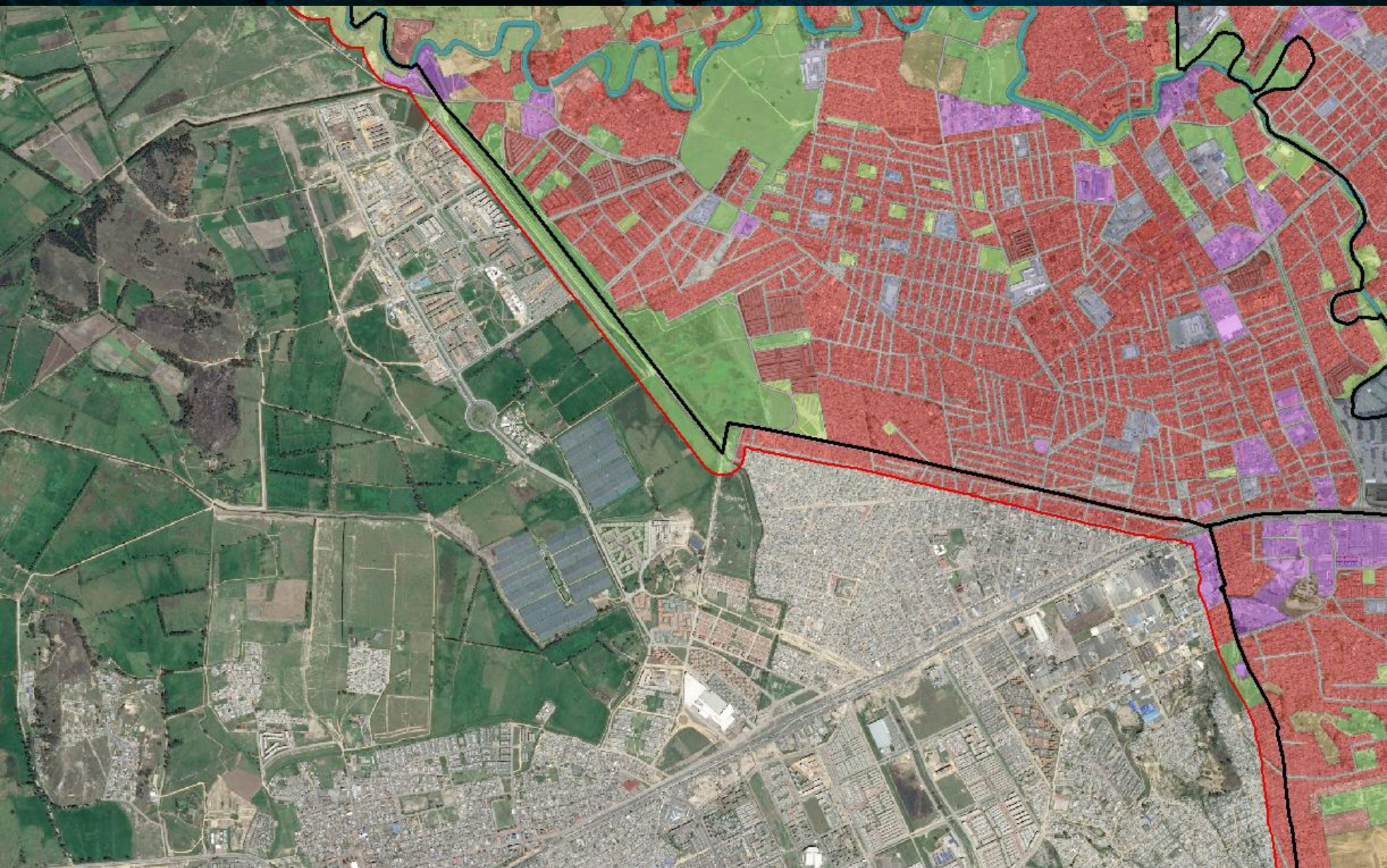
- similar dates
- similar nomenclature Urban Atlas (applied standard)
- easy to combine with other sources
- administrative units



limitations

- subset definition → often related to administrative units
- Suggestion: core area & buffer approach, considering administrative units

Bogota – Urban Area ↔ Area with significant change



example Bogota

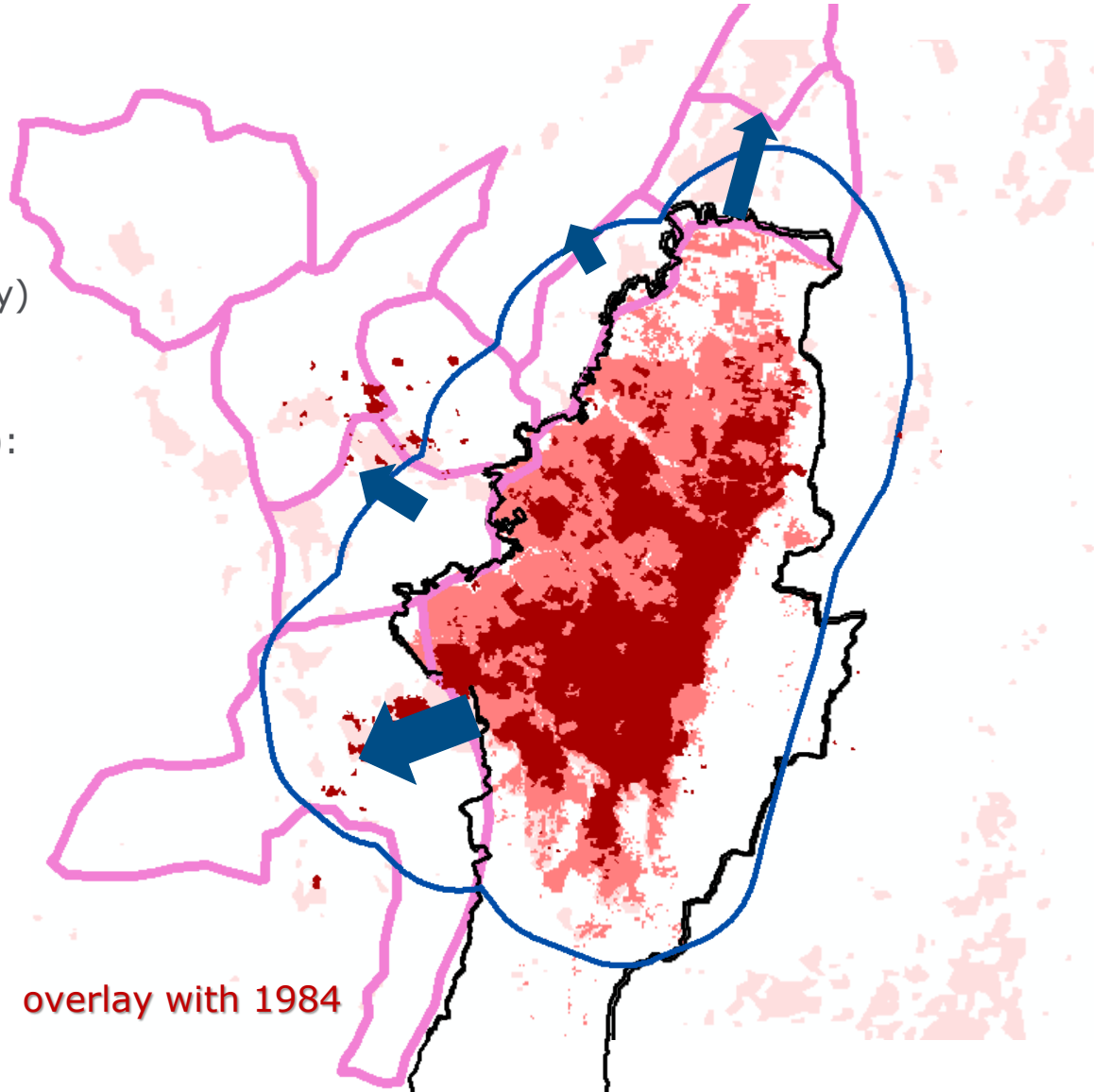
- urban core (up-to-date, draft classification)
- EOworld2 subset for mapping
Mapping result 2013 (Urban only)
- calculation of buffer area (relative to absolute size of city):

$$r(\text{buffer}) = 0,25 \sqrt{A(\text{core})}$$

+ administrative Units:

map & analyse areas
under severe change

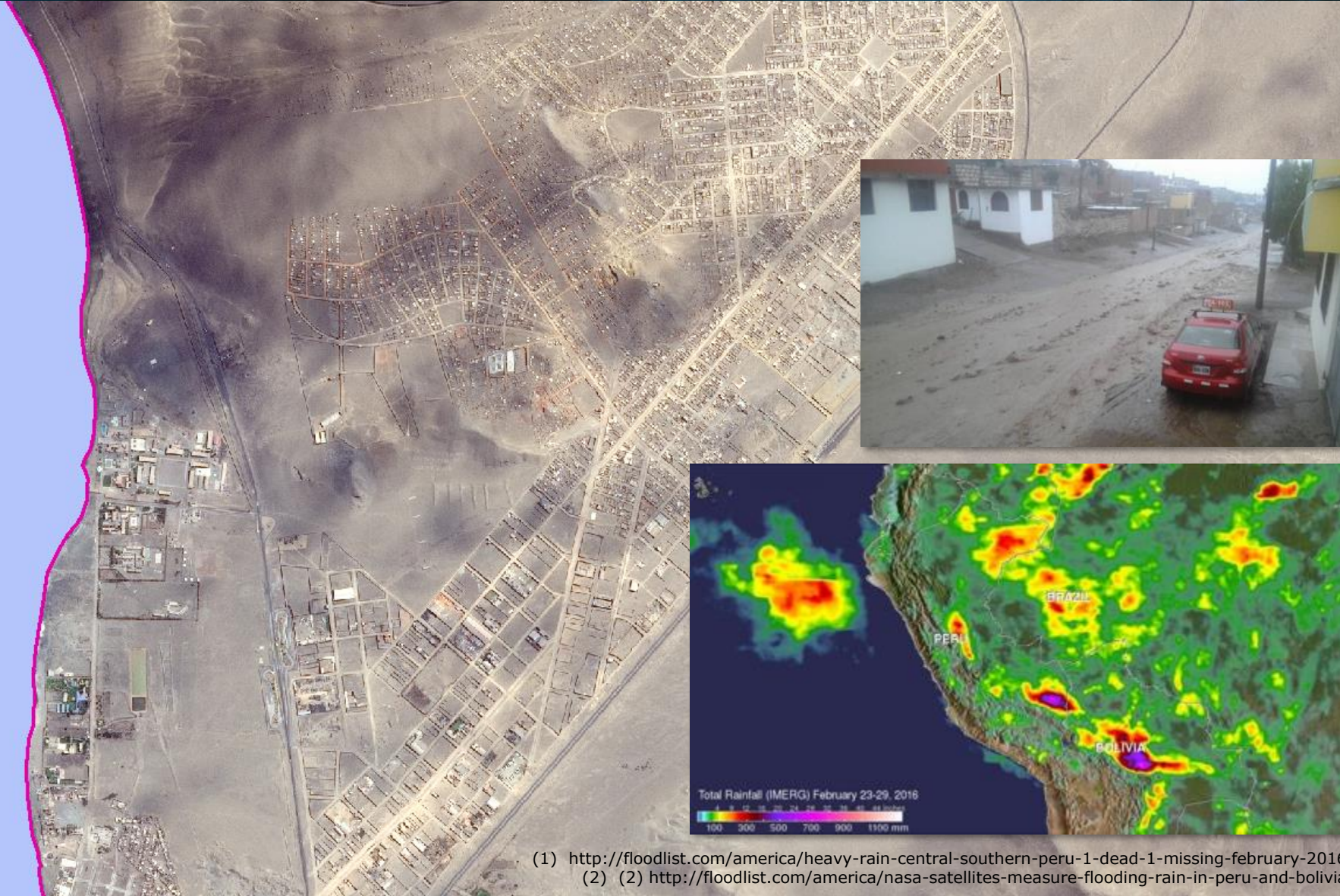
overlay with 1984



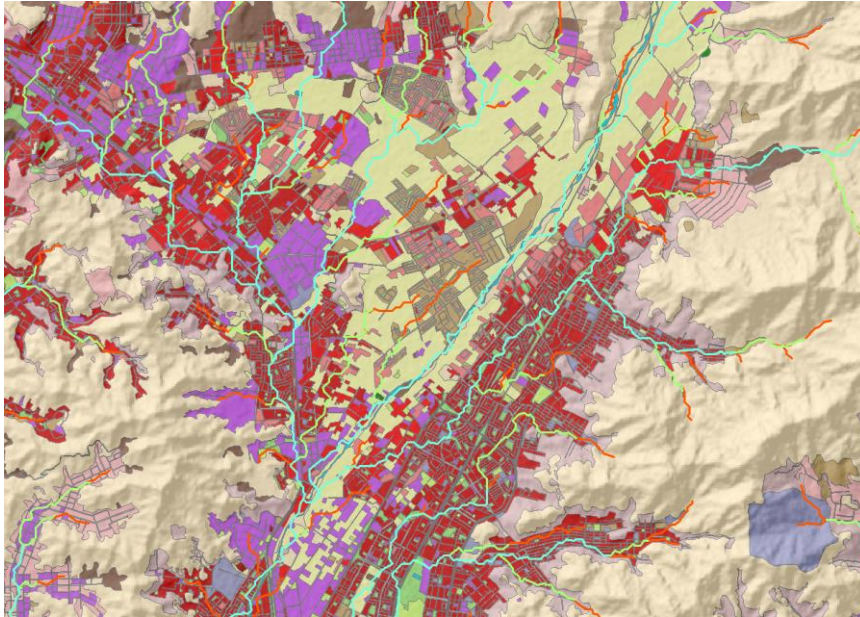
Terrain Information for urban analysis and planning



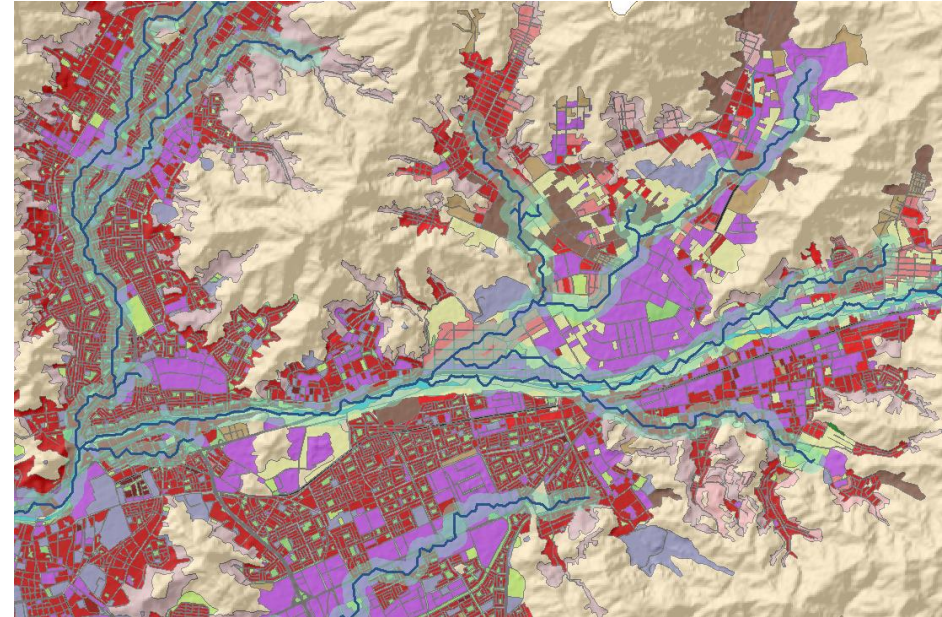
Terrain analysis (risk identification) Climate change effects



- (1) <http://floodlist.com/america/heavy-rain-central-southern-peru-1-dead-1-missing-february-2016>
- (2) <http://floodlist.com/america/nasa-satellites-measure-flooding-rain-in-peru-and-bolivia>

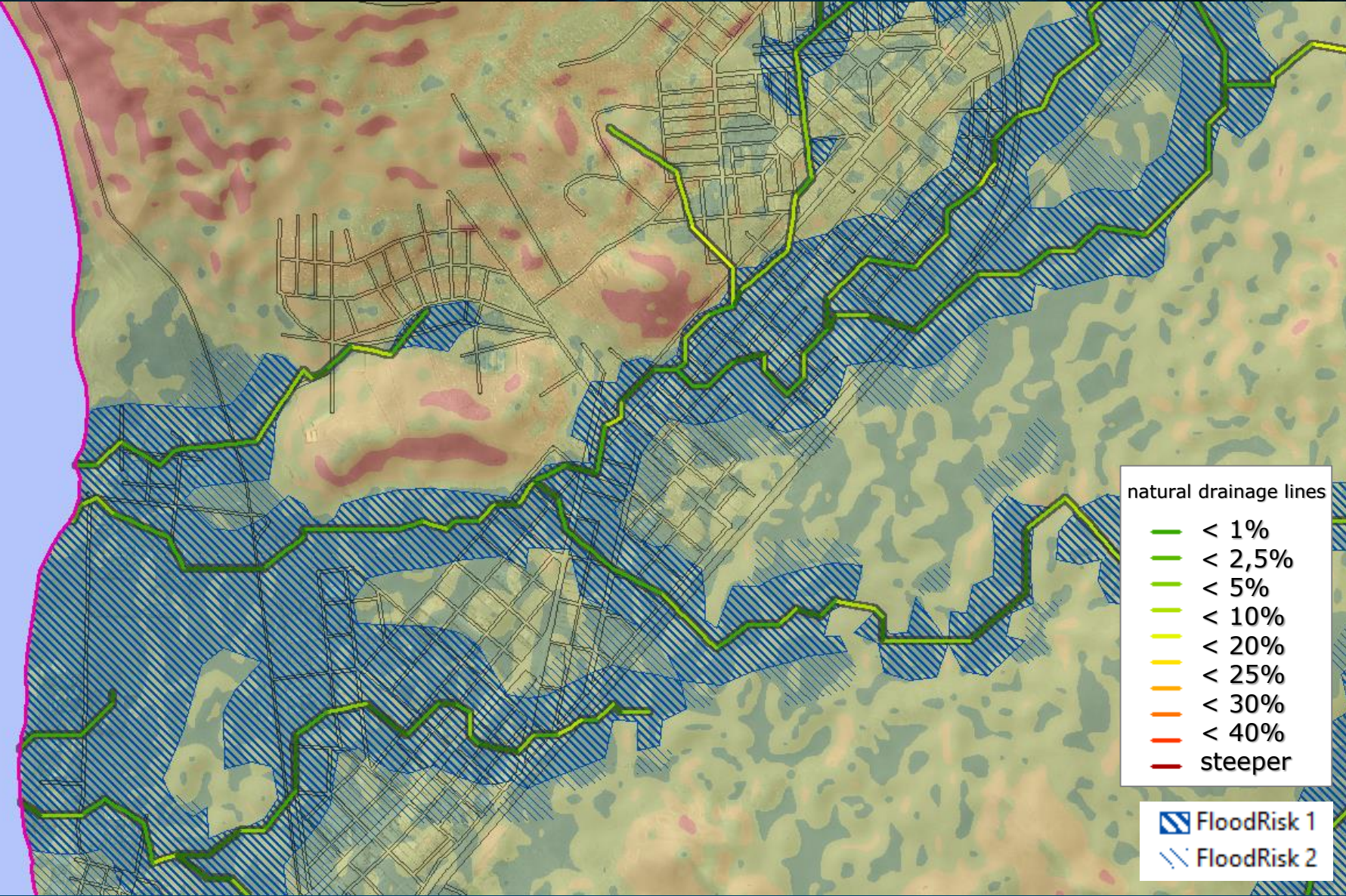


extraction of drainage lines

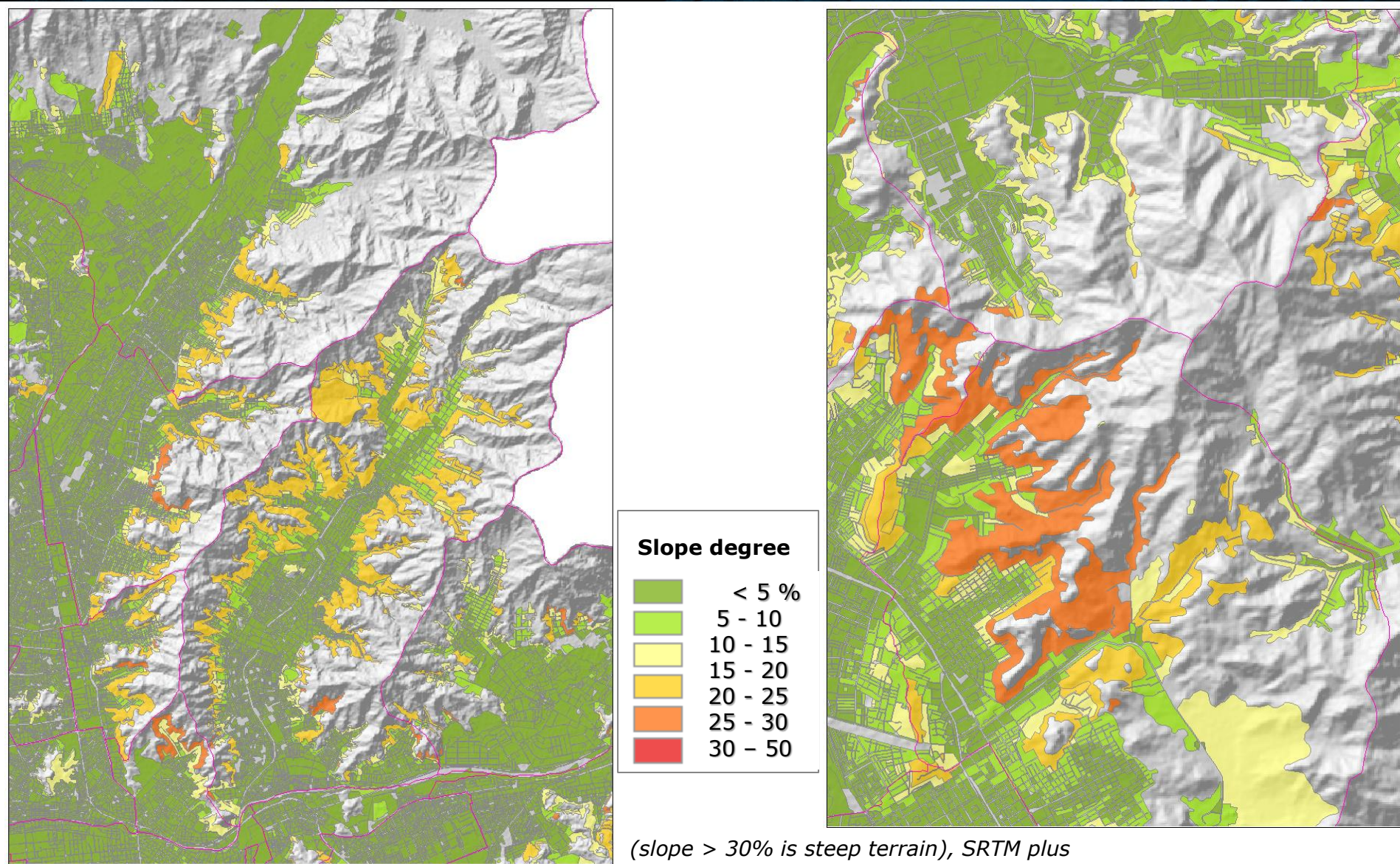


drainage lines and potential flooding areas

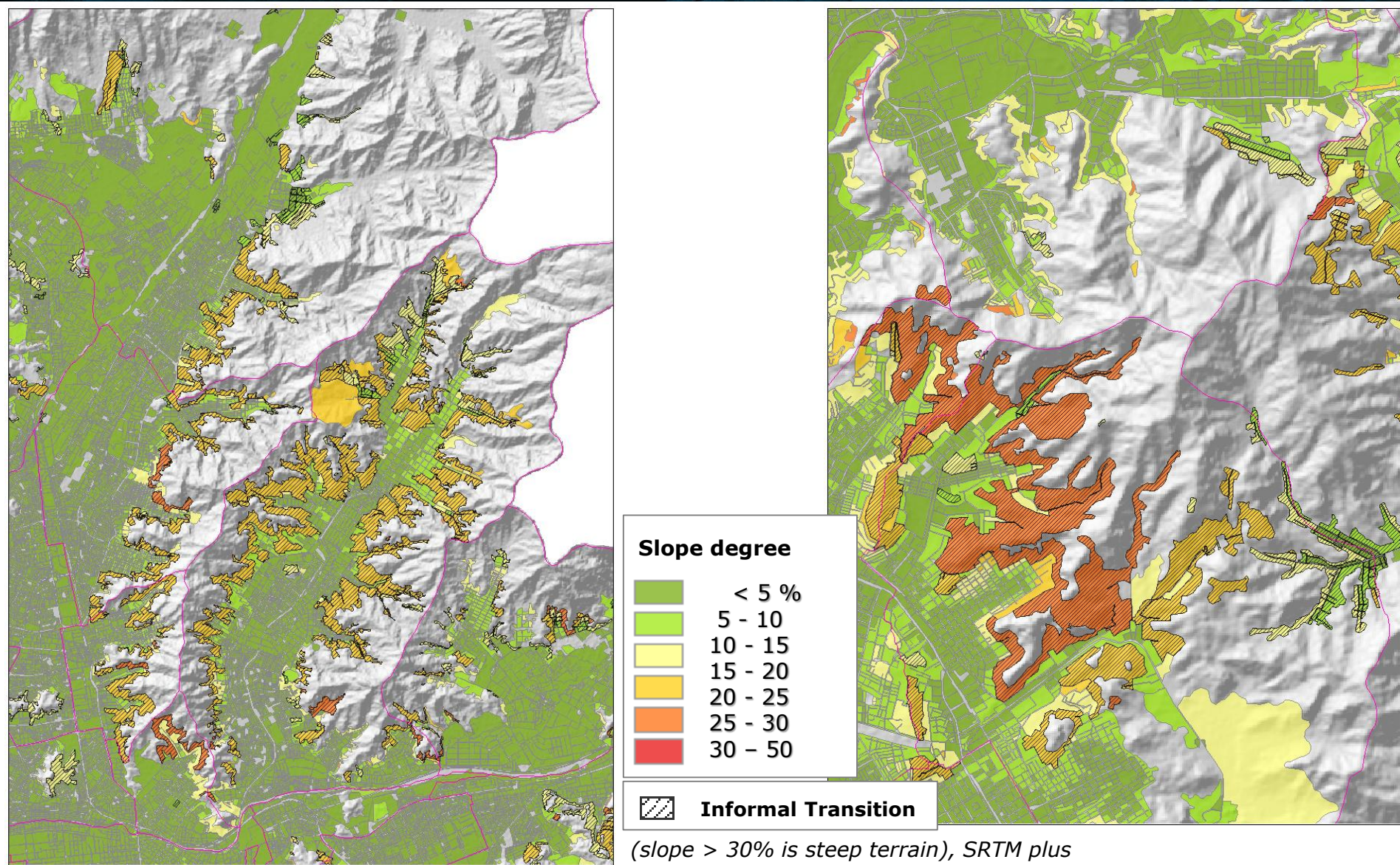
Terrain analysis (risk identification)- potential flooding zones



Slope map suburban Lima – potential landslide areas



Slope map suburban Lima – potential landslide areas

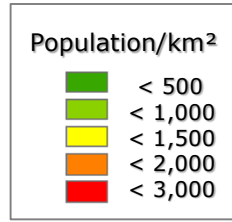
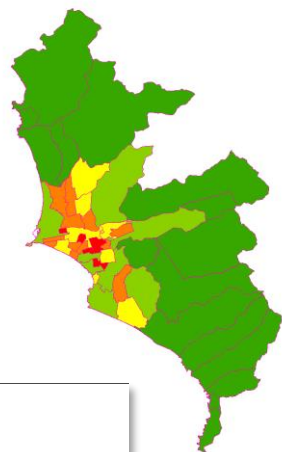


Statistic interpretation

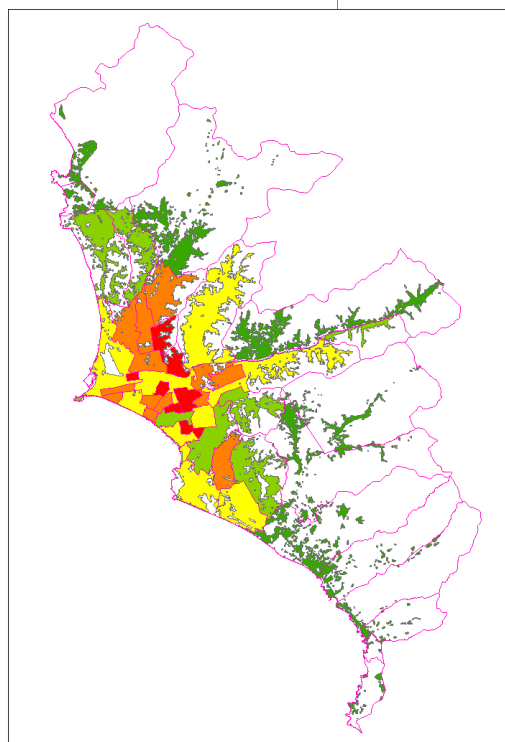
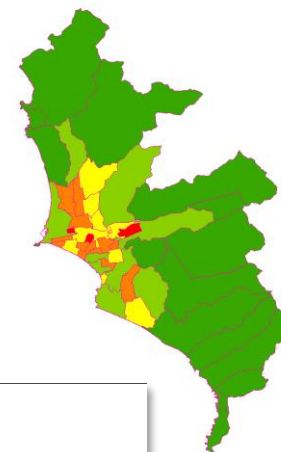
- Link to local available socioeconomic data
 - Population density
 - Employment
 - Income situation
 - Age structure
 - Level of education
 -
- Benefit
 - Information of the **spatial distribution of population in case of emergency** response
 - Input for **urban transport network planning**
 - Information for **planning commercial centres or Industry**
 - Information for **insurance sector**
 - Information for **planning of recreation areas** in urban areas (green and blue space)
 - Information for education sector
 -

Population density – transporting the message

Lima, 2007



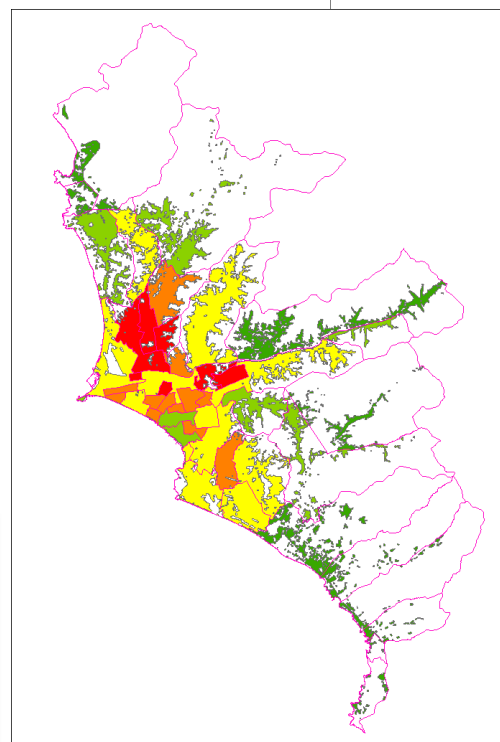
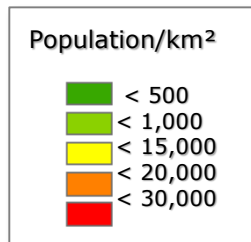
2013



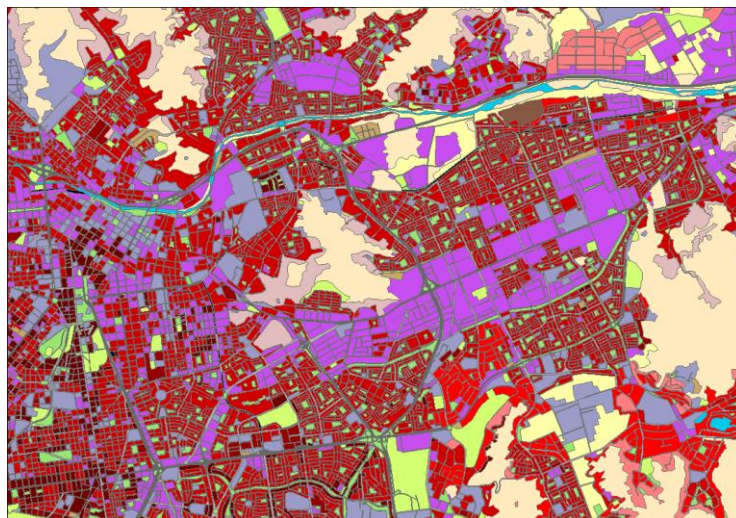
example:
population density (Lima)

statistics related to absolute
extent of administrative
area are often not suitable/
pretent a different reality

real change can only be
seen related to
absolute urban footprint

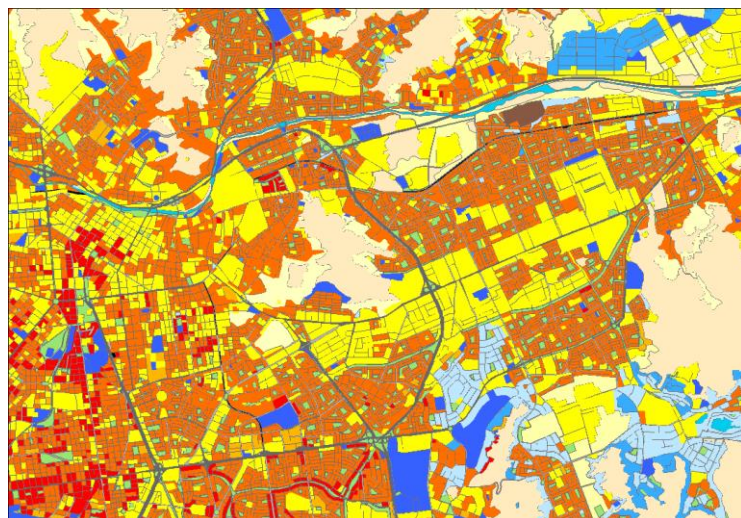


Population density

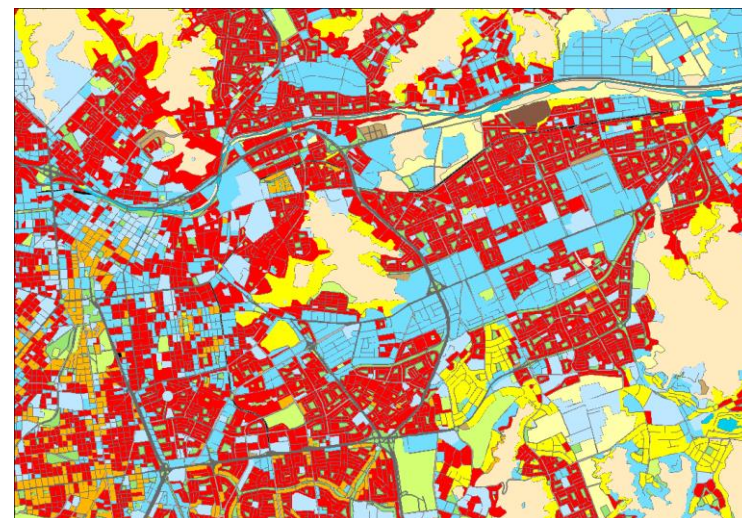
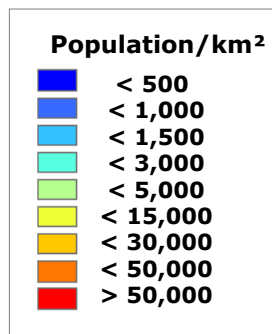


based on
Urban Mapping Service

and some sort of population/
commercial information
(often of different kind, but can in
general be transformed to suitable
information for modeling)

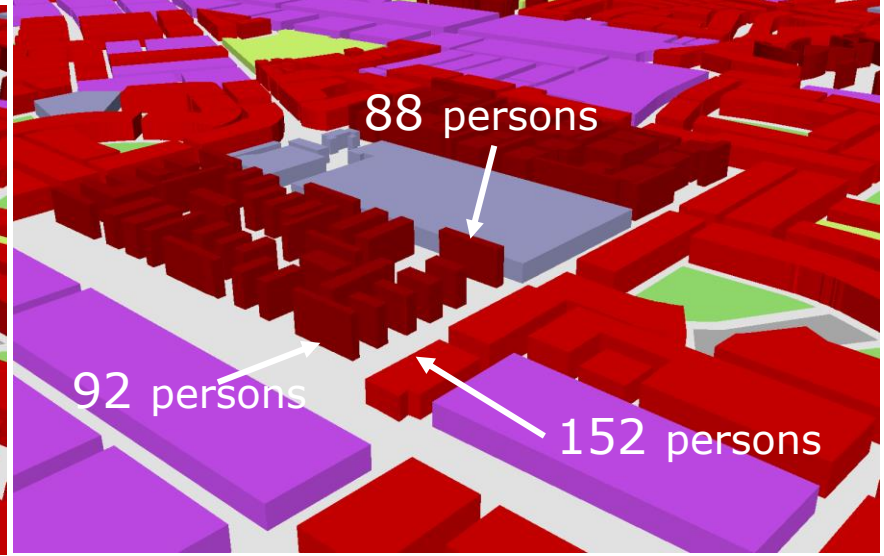
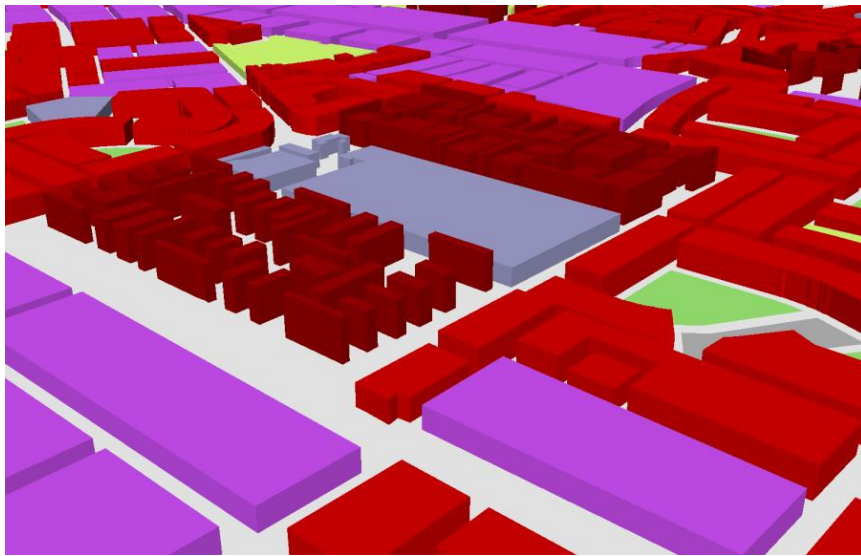


population estimation day-time

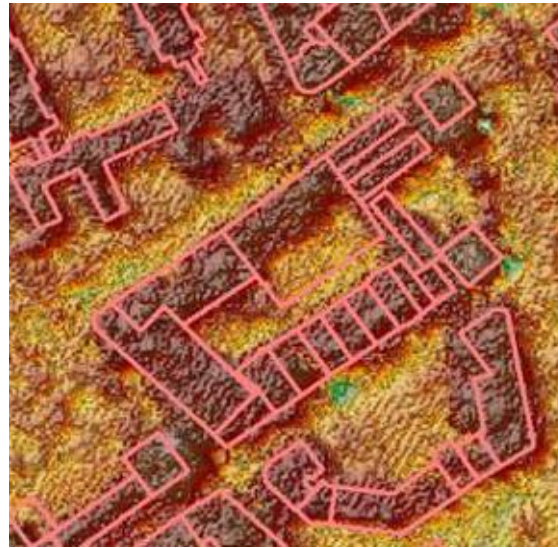


night-time

Derivation of 3D Information for the estimation of inhabitants



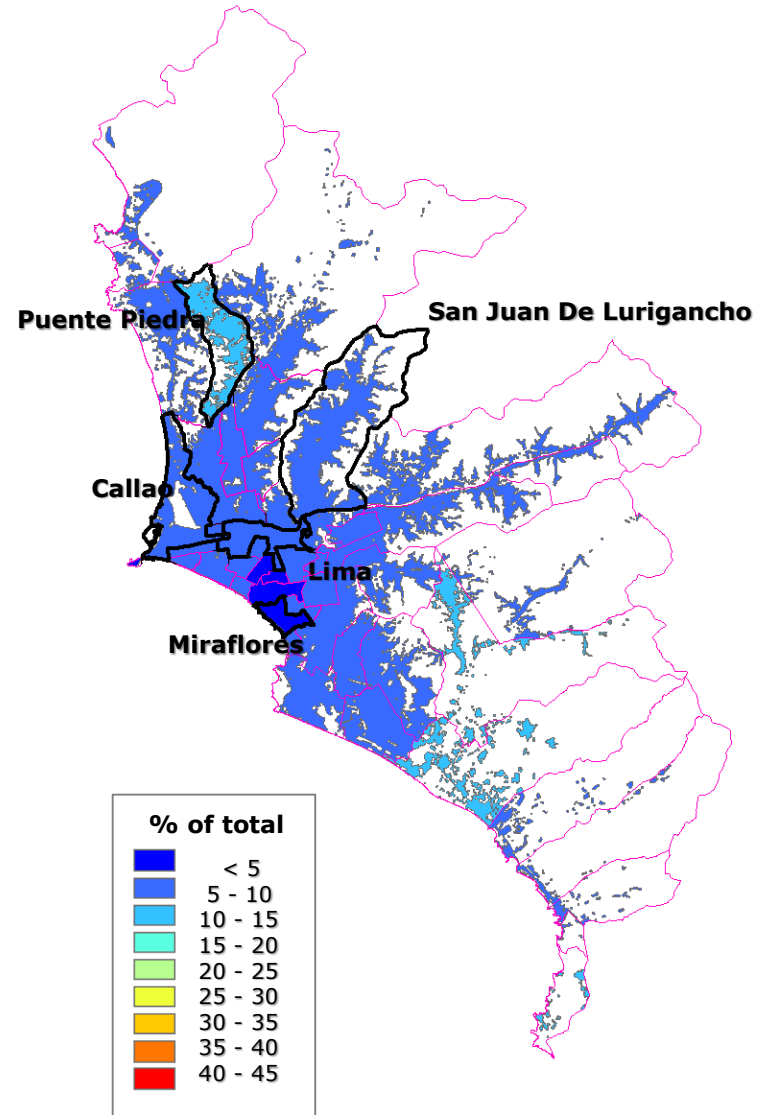
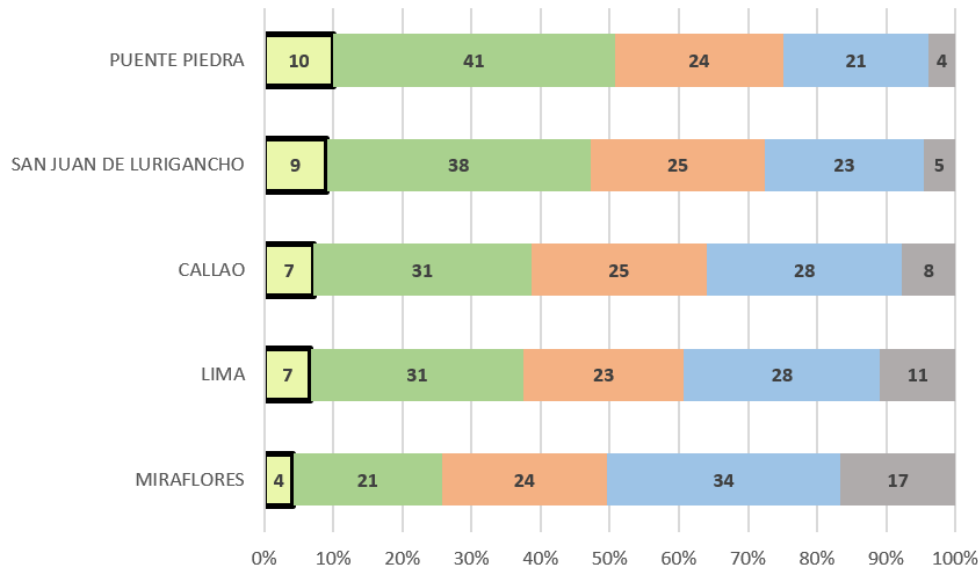
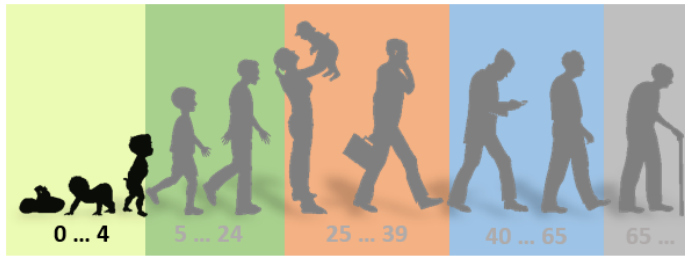
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3D point cloud from Spot 6 stereo data

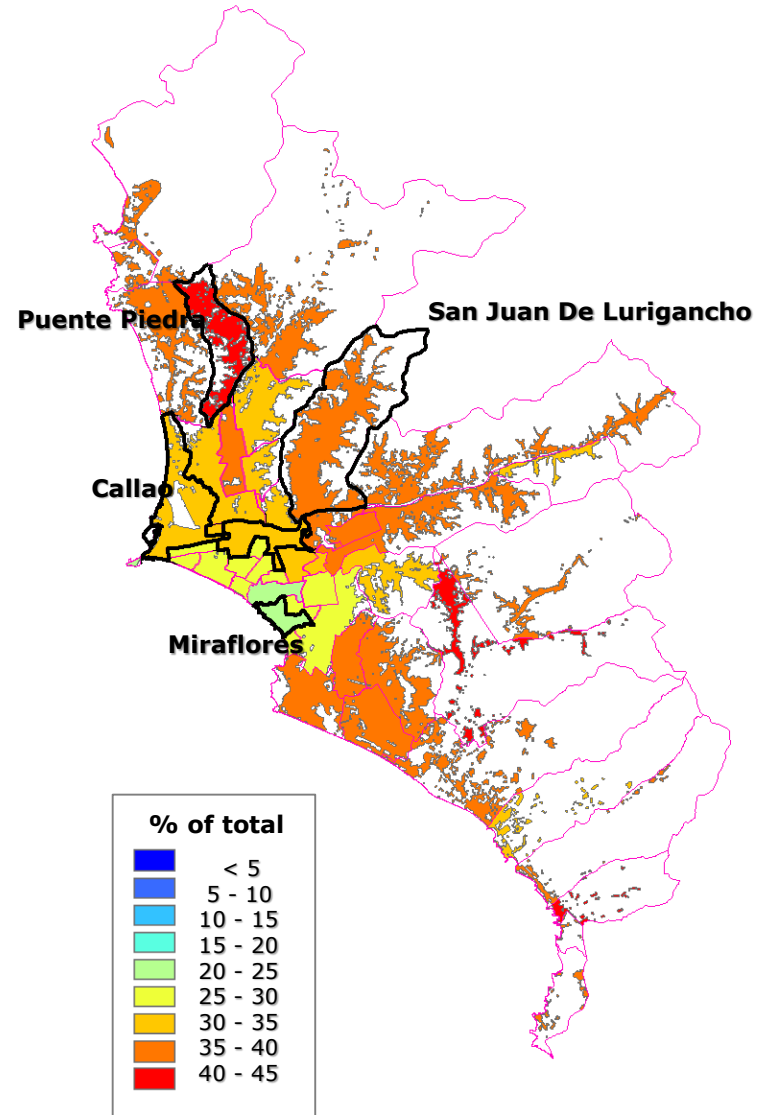
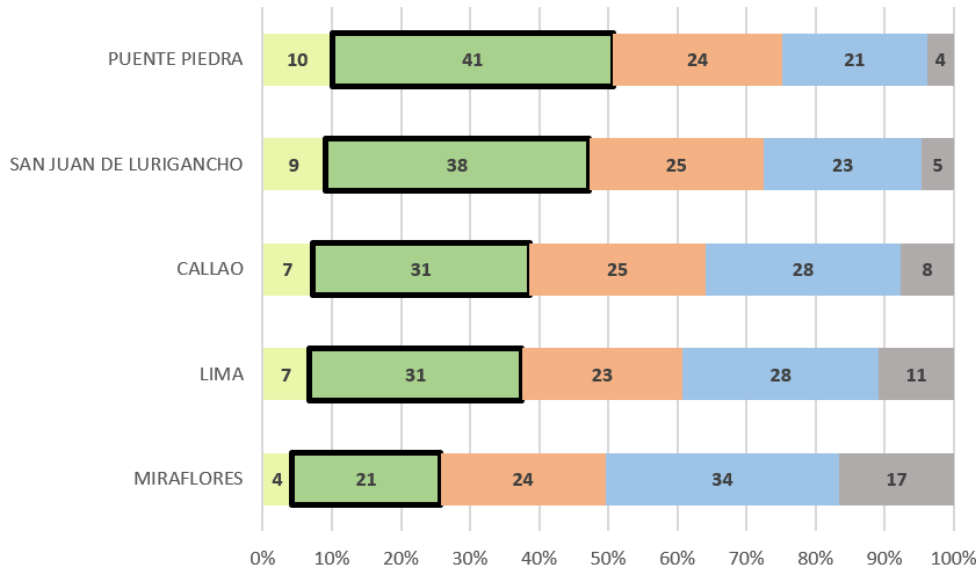
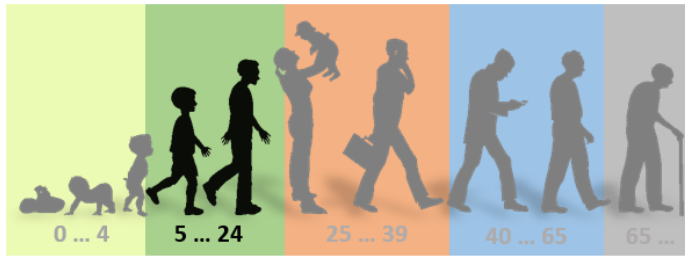
Population Structure (District of Lima, Peru)

Age class below 5 years (source: INEI of 2013)



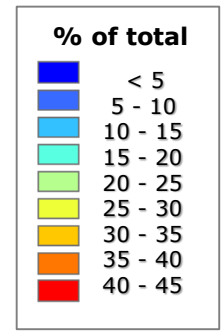
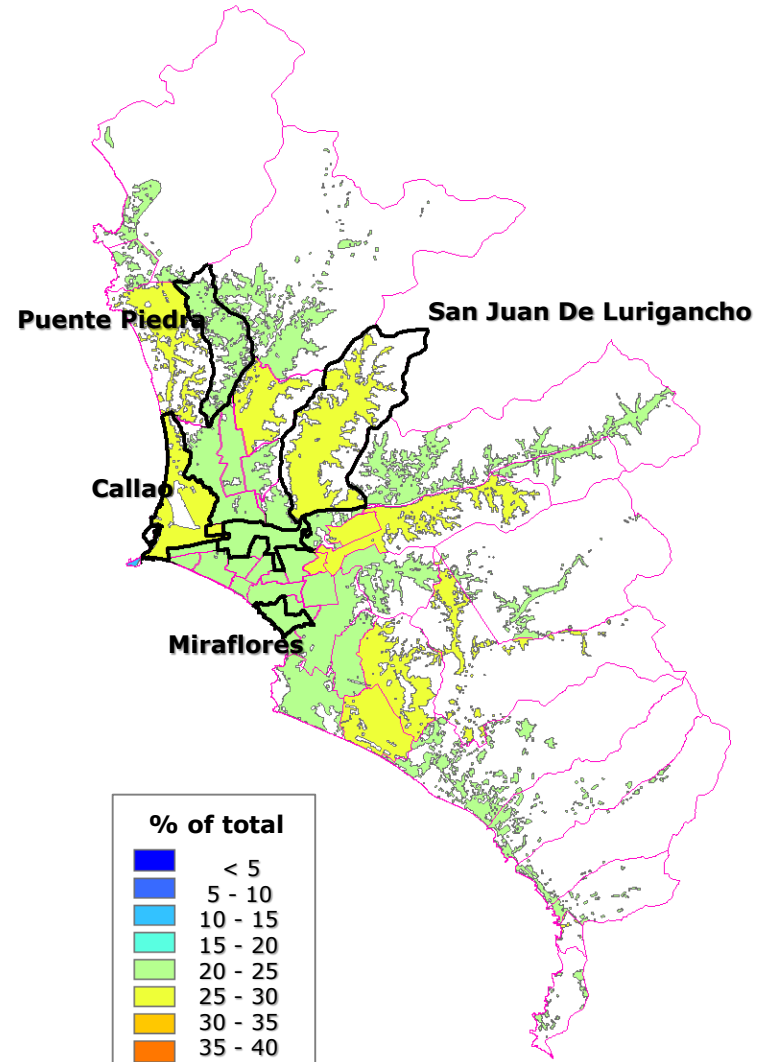
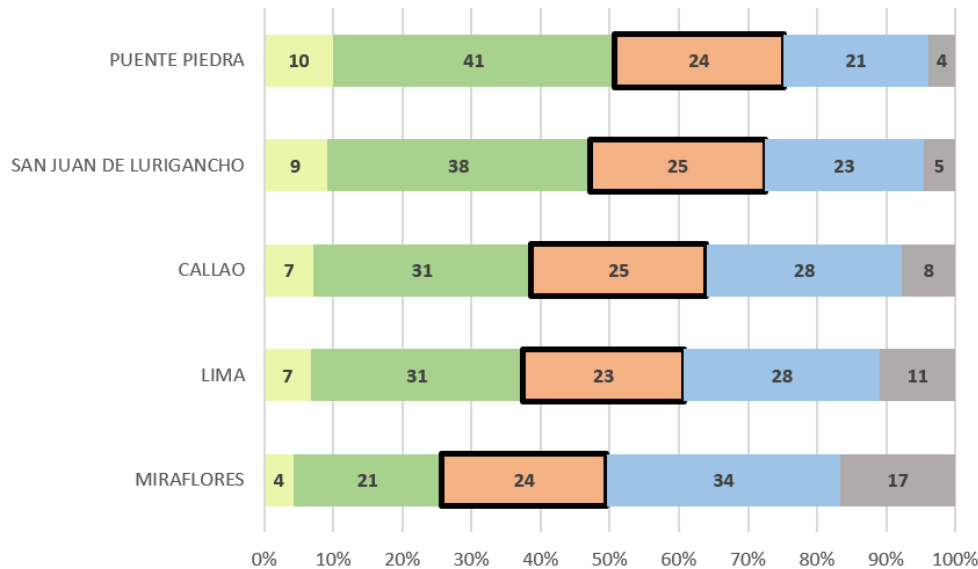
Population Structure (District of Lima, Peru)

Age class below 5 – 24 years (source: INEI of 2013)



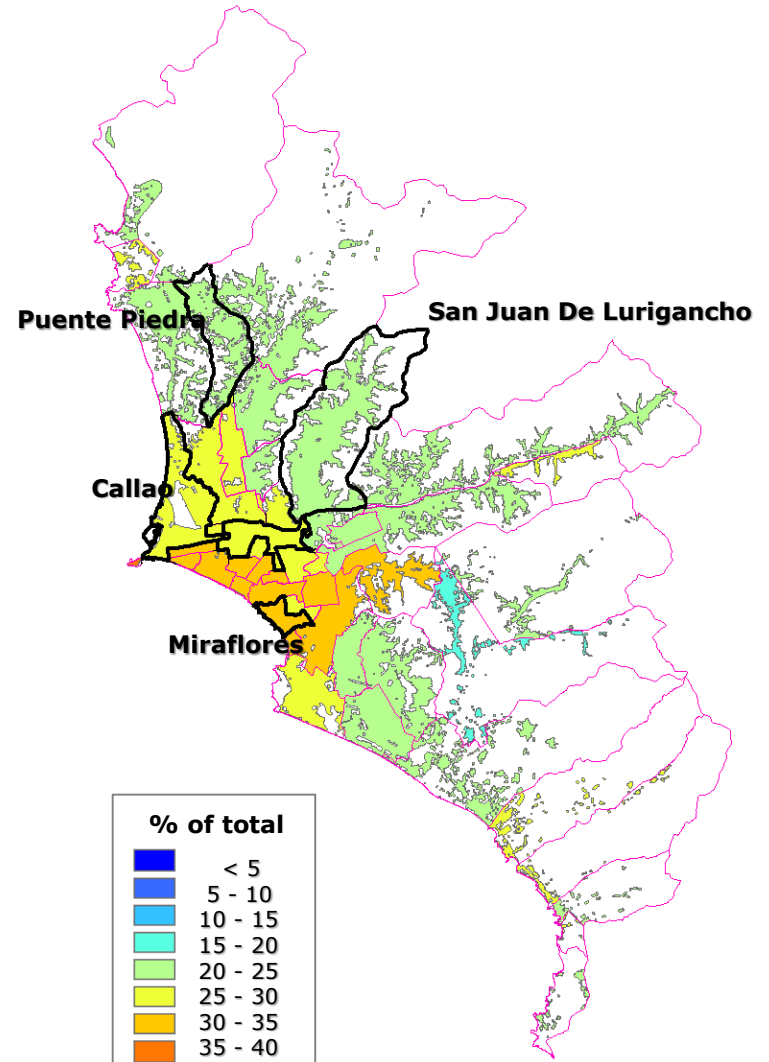
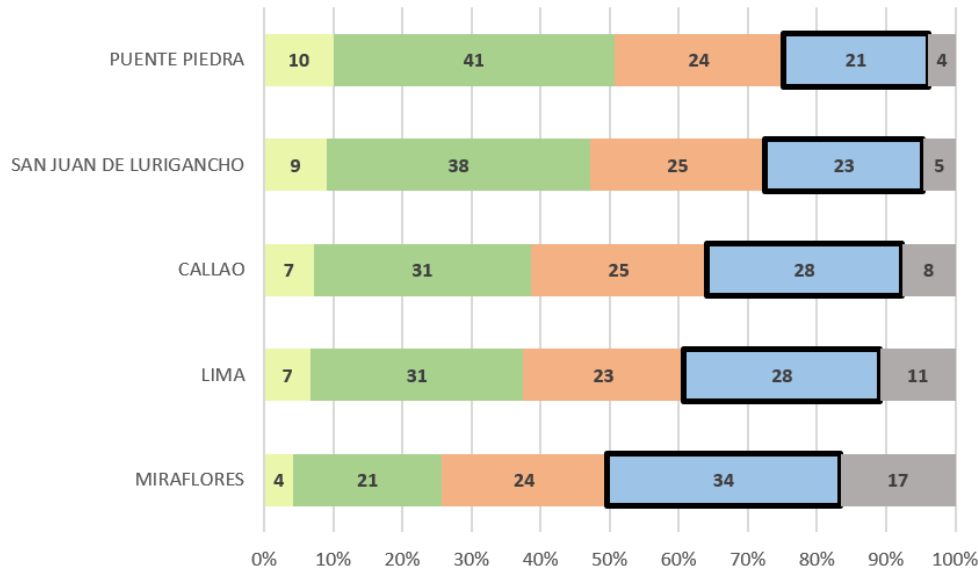
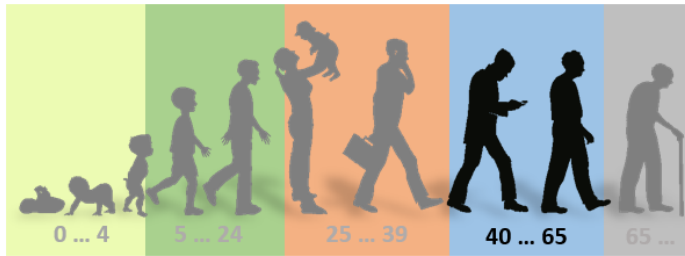
Population Structure (District of Lima, Peru)

Age class below 25 – 39 years (source: INEI of 2013)



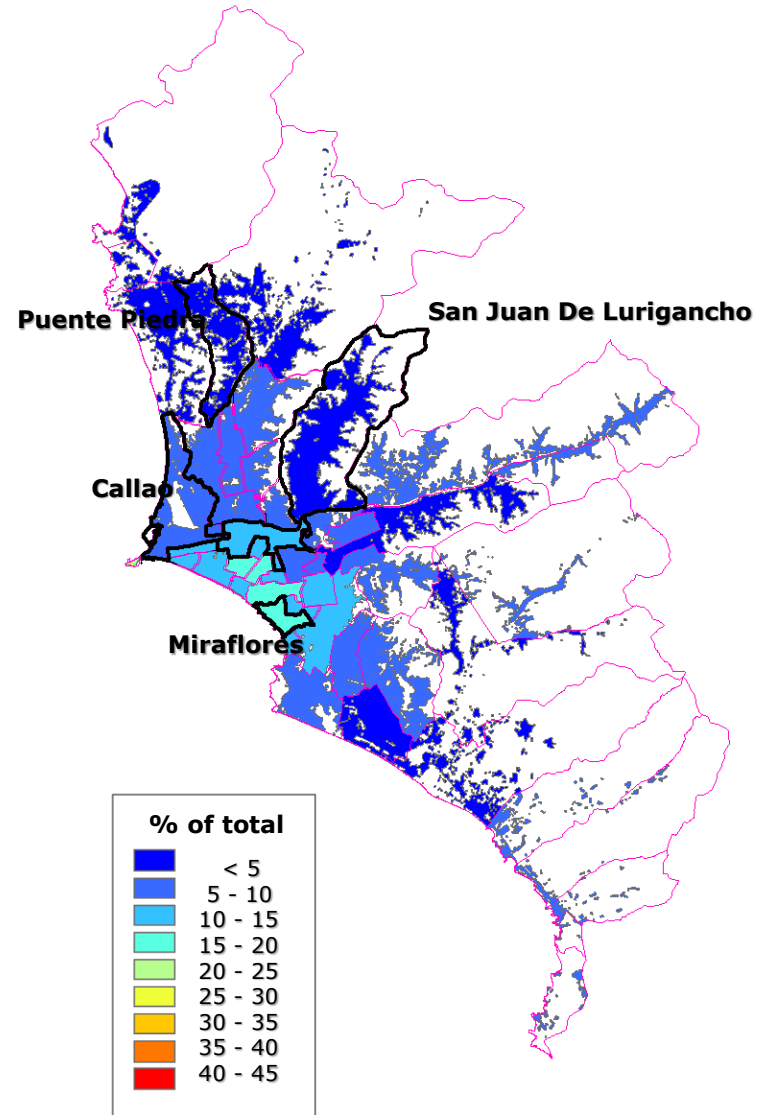
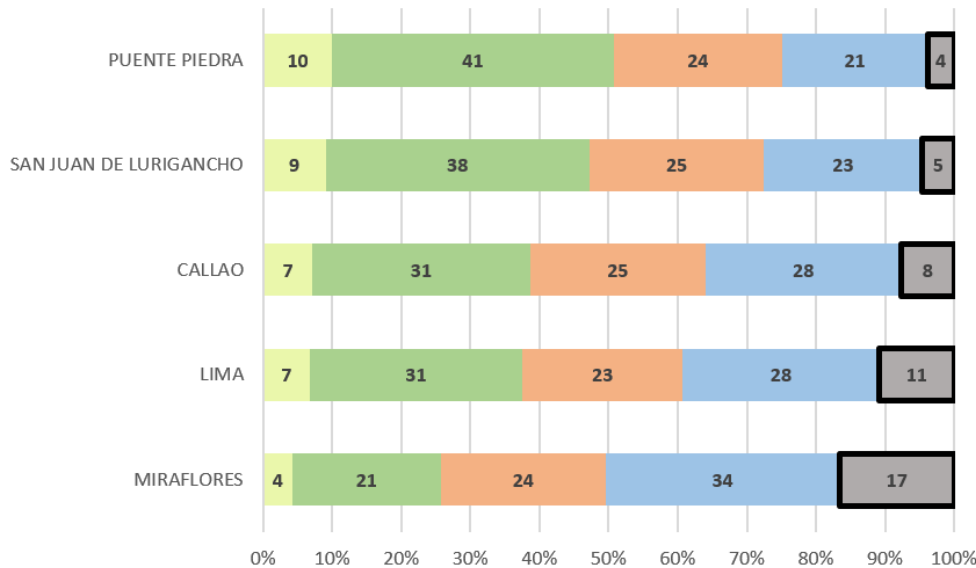
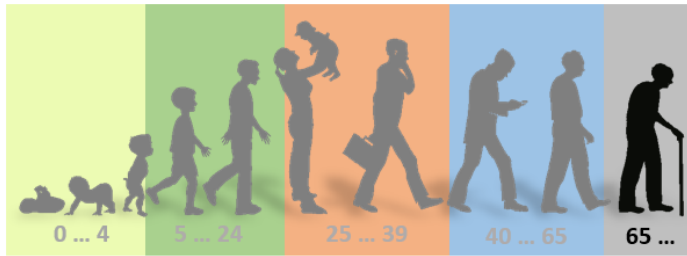
Population Structure (District of Lima, Peru)

Age class below 40 – 64 years (source: INEI of 2013)



Population Structure (District of Lima, Peru)

Age class 65 years and older (source: INEI of 2013)



Main benefits:

- **Standardized process** for urban mapping and analyze in mid-scale level for data scarce areas
- The retrospective view give us useful **information of urban growth patterns**
- **Cost & time efficient** way to derive geospatial information about the urban structure
- Link to socioeconomic data – **data fusion**
- **Detection of hotspot areas** for natural hazards (vulnerability)
- Important input to make the urban area **more resilient**

Main aspects of using EO information

“It is mandatory to **understand the users processes** and daily work”

„The real benefit of EO is to **provide information** derived from different sources, **tailored for the users business processes**”

Thank you for your attention

IABG mbH

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