LUXEMBOURG INSTITUTE OF SOCIO-ECONOMIC RESEARCH

Smart cities Symposium international

BUILDING HEIGHTS IN LUXEMBOURG CITY

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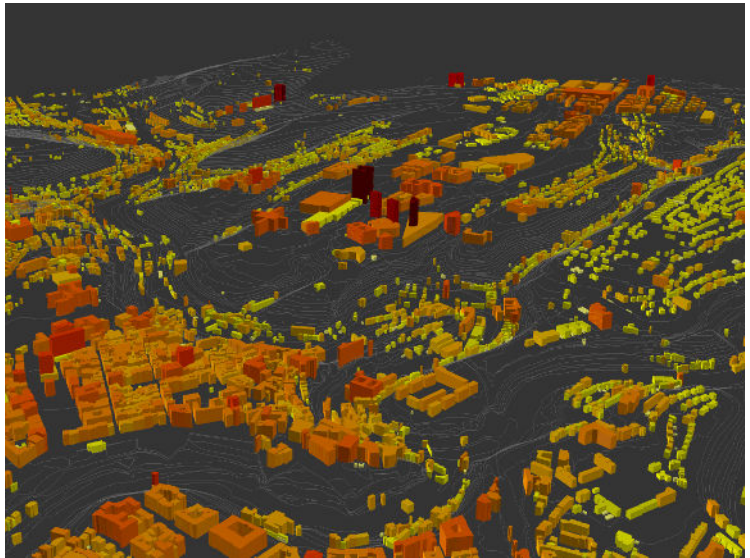
BuildingH_Hichem4.mp4



Context and problem statement

Context:

- Due to limited land resources for construction and the need to preserve natural and agricultural areas, **vertical** densification seems to be an "intelligent solution" to support sustainable urban growth.

→Urban planners (and other urban actors) need information and monitoring tools to better manage the development of building stock and building heights and to improve various aspects of urban planning (e.g., water supply, energy efficiency, services and green spaces).

Problem statement:

→ Lack of proper tool in the country

Research questions and statement

Research questions:

- How to measure building heights automatically at the city/country scale?

- Where to densify reasonably in the future?

Statement:

LiDAR data are effective to do so…

Aims

- Measure automatically the building heights in Luxembourg-City using LiDAR data (2017).

- Develop a prototype based on a high resolution 'normalised' digital surface model (nDSM) derived from LiDAR point cloud data (source: ANA*-ACT https://data.public.lu).

* Administration de la navigation aérienne *https://ana.public.lu/*

Challenges

The use of LiDAR data is complex, and its application raises many challenges, such as:

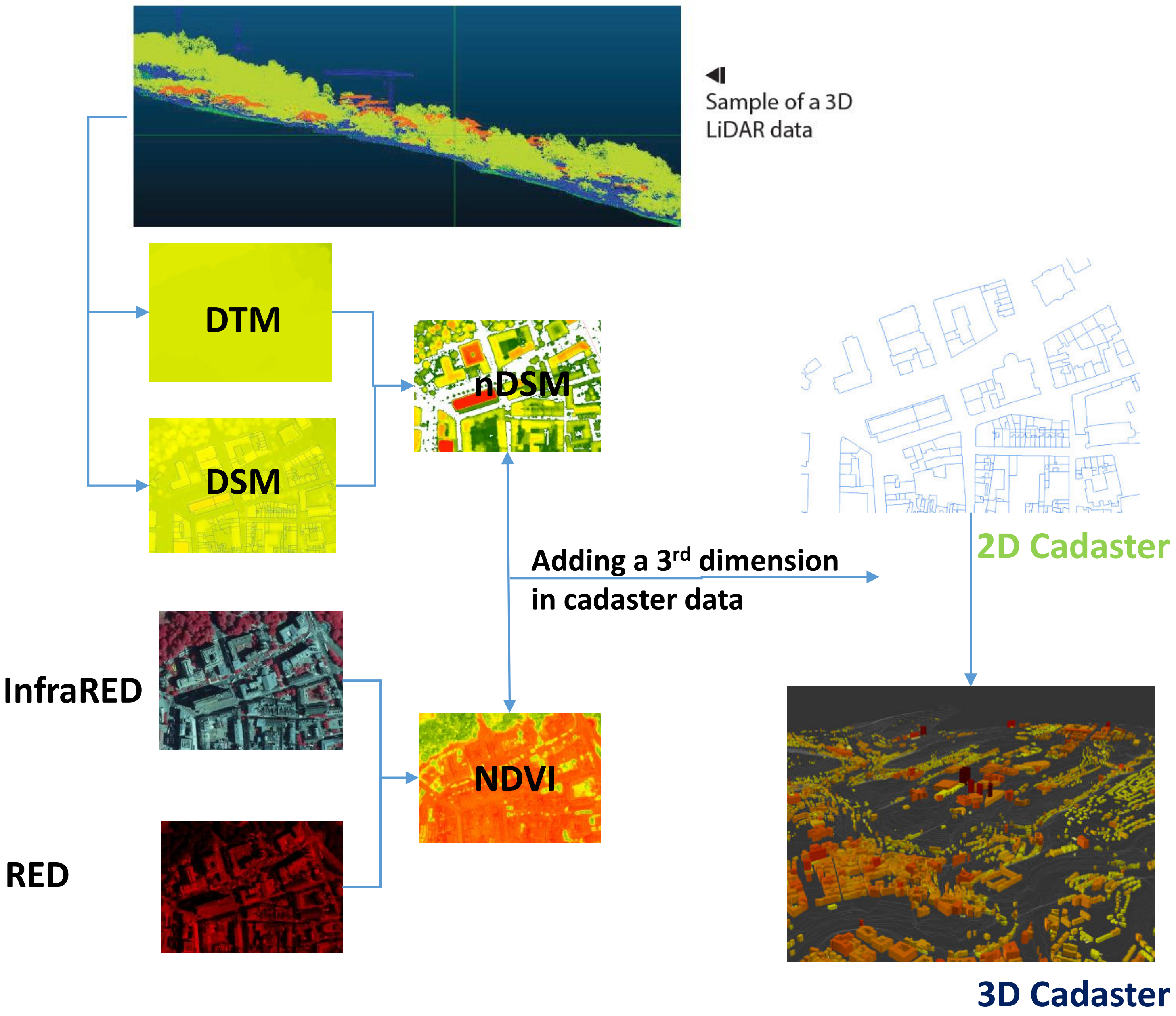
- Handling large amounts of data,
- Automated feature detection and extraction,
- LiDAR data/points classification,
- Automatic error correction in LiDAR data (e.g., tower crane on a construction site, car in a street, etc.).

Data and steps

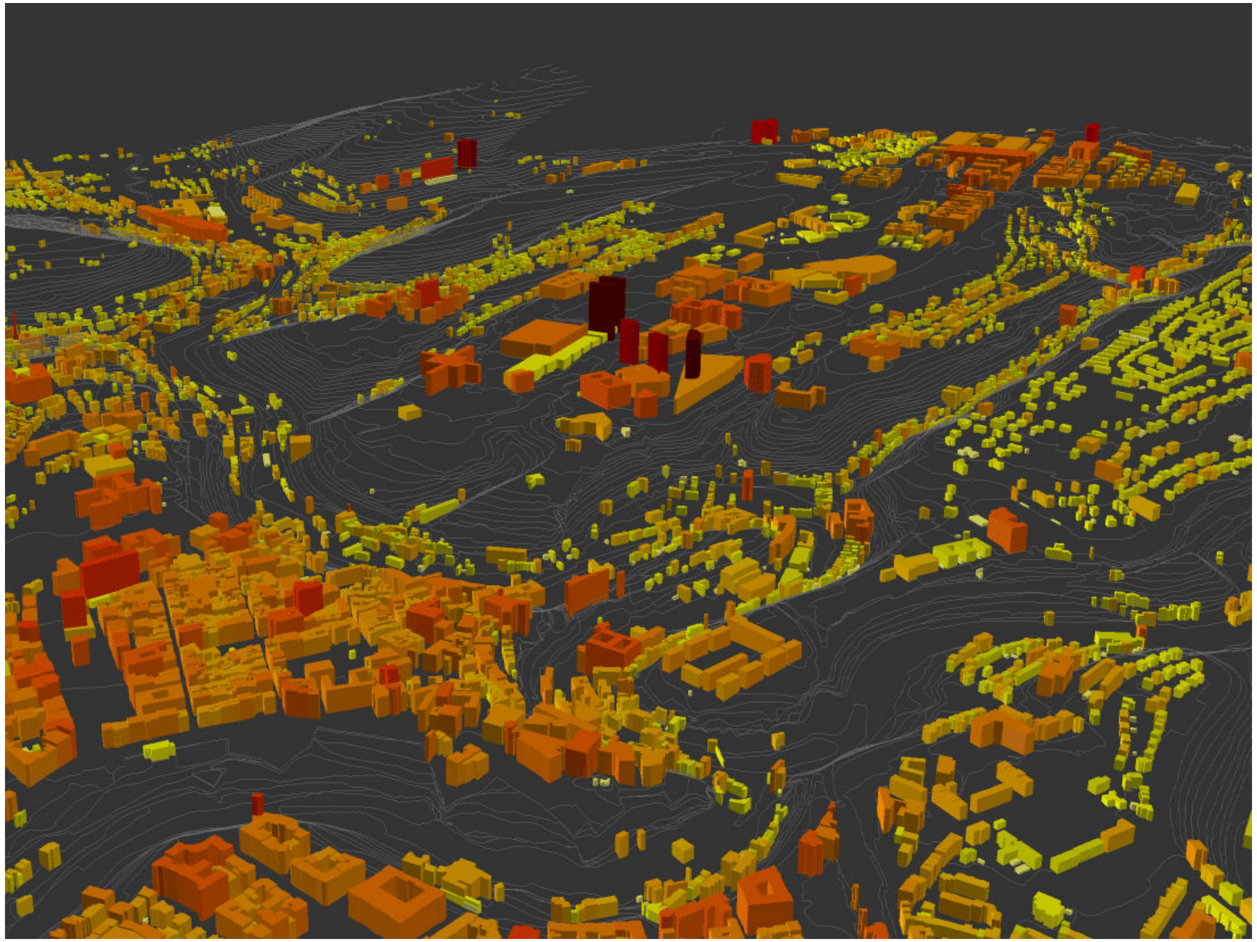
- data.public.lu

It was created by performing the following operations:

- Subtracting the influence of the topography on the object height (i.e., the difference between the digital surface model (DSM) and the digital terrain model (DTM) (nDSM= DSM-DTM).
- Using a normalized difference vegetation index (also called NDVI) to keep only objects without vegetation.
- Combining the new data (i.e., nDSM) with cadastral administrative data to identify the types of buildings.



Mapping of building heights



3D visualization of building heights in Luxembourg-City in 2017

Promising results: as the tool was able to quantify the heights of all buildings (cf. Figure)., with great <u>accuracy</u> and a <u>very fine vertical resolution</u> (1m).

This decision-making tool offers valuable assistance to all urban actors and allows to:

• Enrich the administrative data of the cadaster,

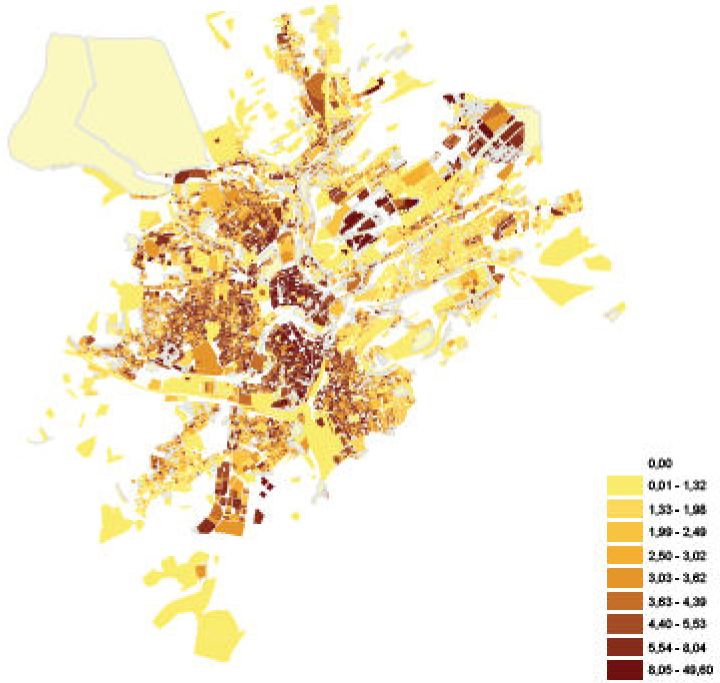
• Monitor the building heights,

• Create a 3D vertical cadaster of buildings, with accurate heights.

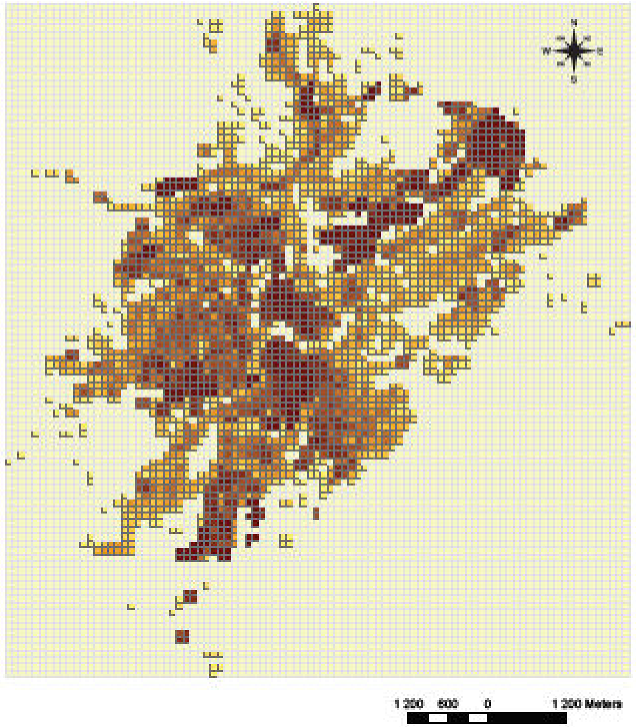
Urban volumetry index in Luxembourg city

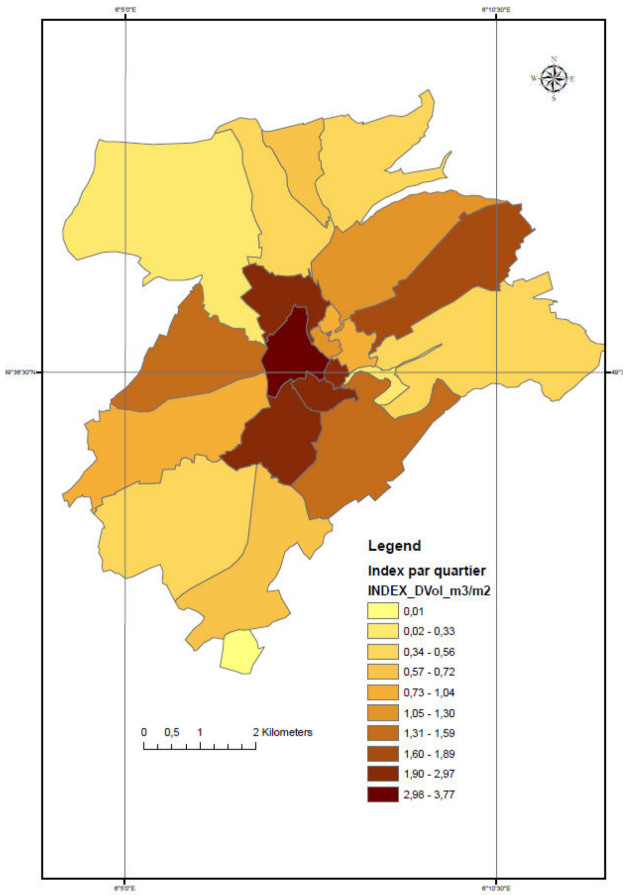
Urban volumetry index in Luxemburg city

▼Parcel (m^3/m^2)



▼Resolution (100x100)





Distribution of urban volumetry index among quartiers

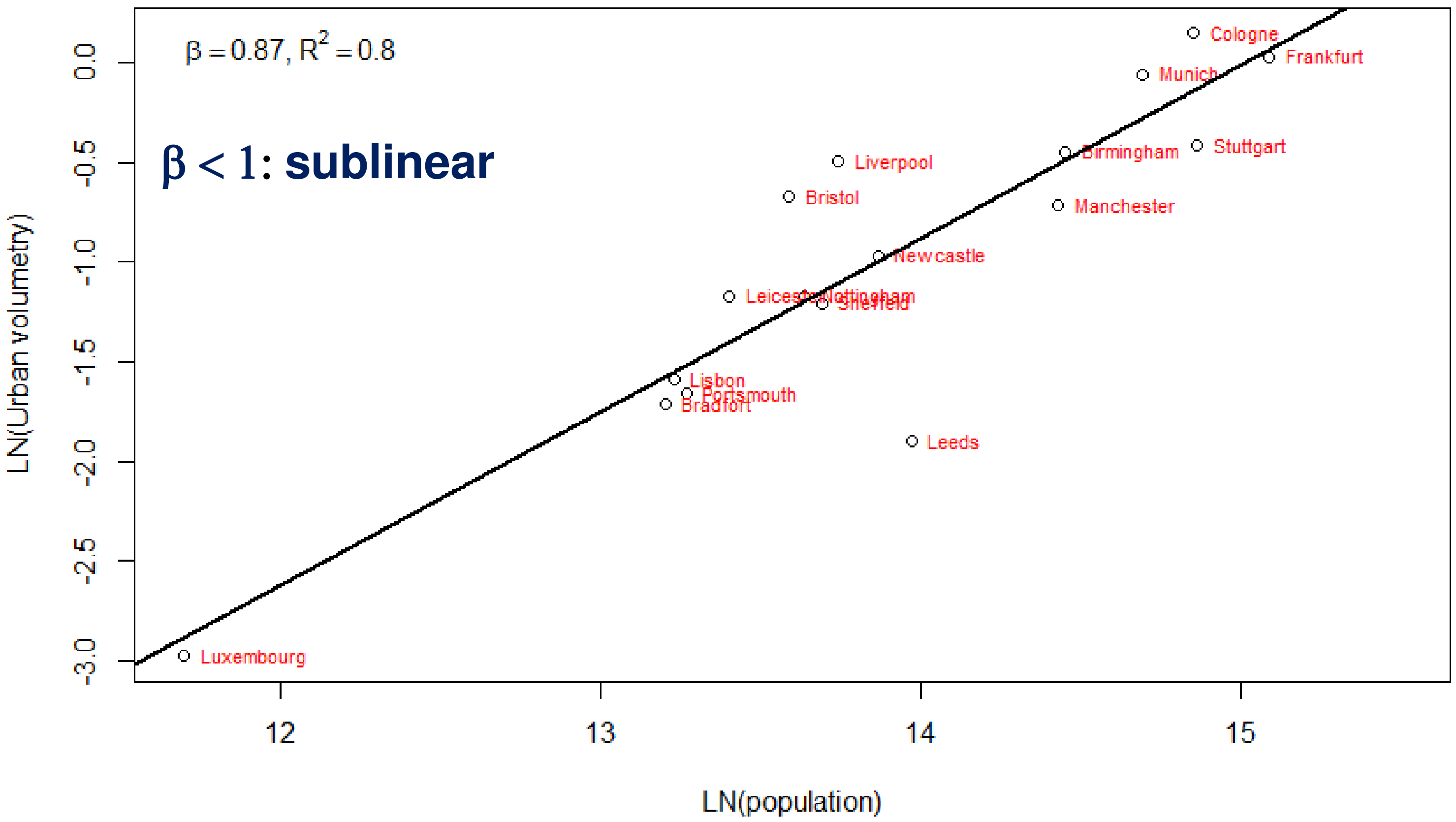
Built Volume per capita for Luxembourg city in 2017

Population (hab)	Built Volume (km3)	Built volume per capita (m3/hab)
120,000	0.051	425

Urban scaling

Power-law relationship between
Population size
and
Urban Volumetry (in *km3*)

Power model: Y = a X$^{\beta}$



Summary and future work

Summary:

- The developed “SmartGrowth” tool measures **automatically** building heights in the city **with high precision**.

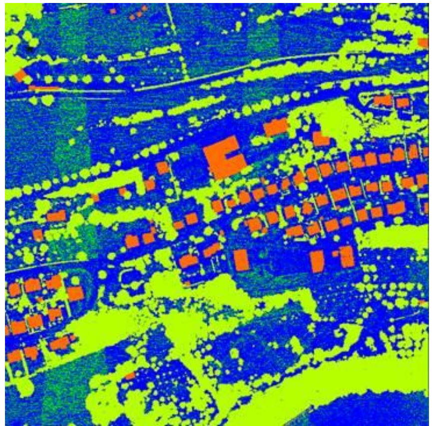
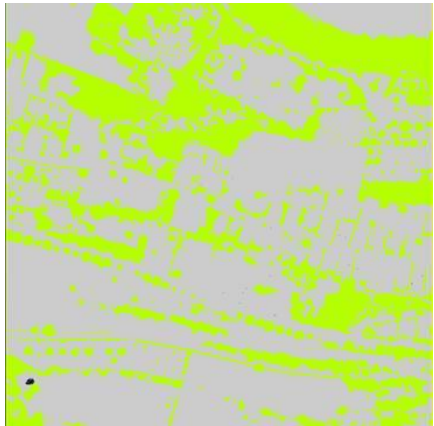
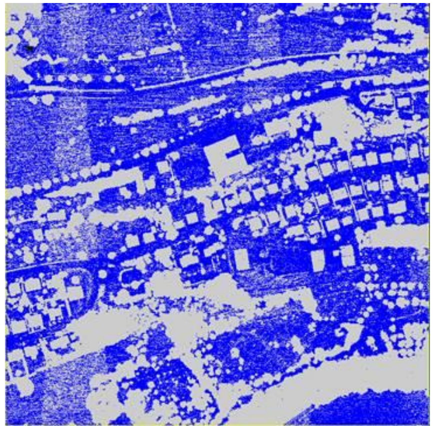
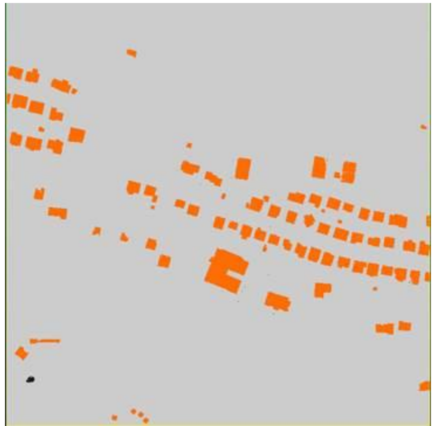
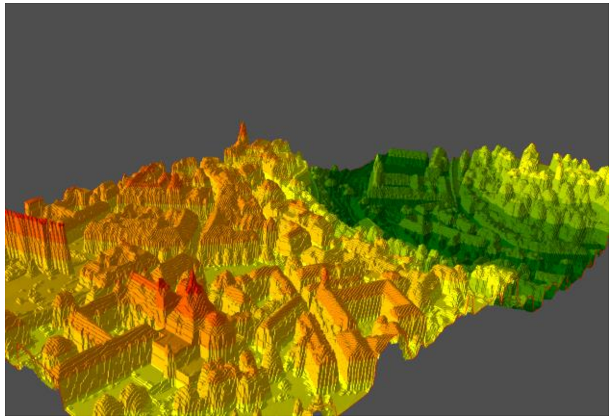
- This tool is intended to help in the building stock monitoring (residential, commercial, …)

Future work

- **Detect automatically the obstacles that people with reduced** mobility and cyclists may face, on a very fine scale. This detection will better develop the city of tomorrow and make it more inclusive,
- **Simulate future densification** to accommodate future generations using urban simulation tools such as those already developed at LISER in recent years as part of several competitive research projects funded primarily by the FNR (e.g., Smart.Boundary, Moebius , Connecting),
- **Assist with land use planning** for more sustainable urban housing management to ensure "smart" city growth,
- **Evaluate the solar potential** on the roofs of buildings.

Thanks for your attention

QUESTIONS !

Home-take message:

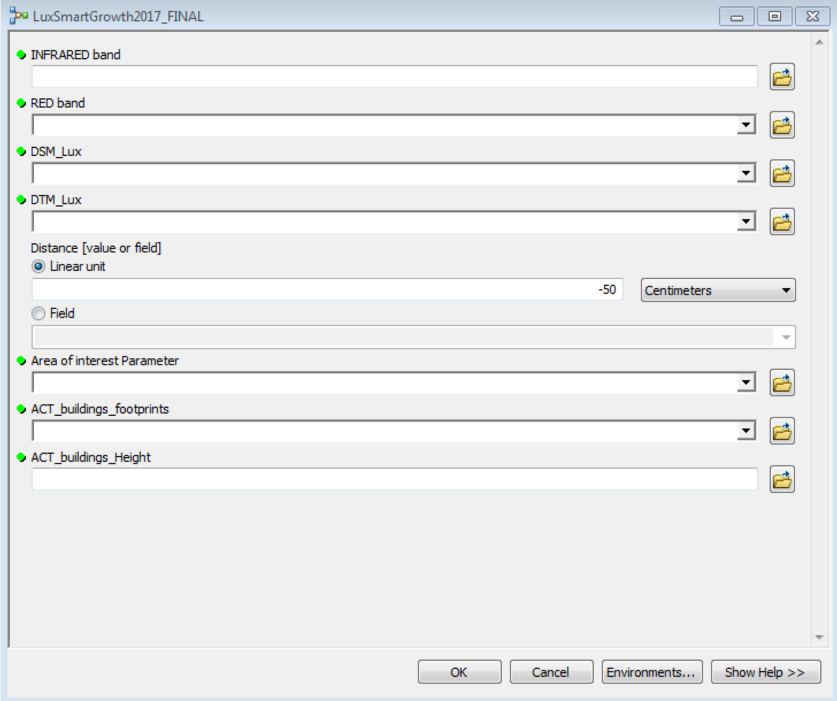
Vertical densification, around transit stops, seems to be a solution for Luxembourg to solve the problem of

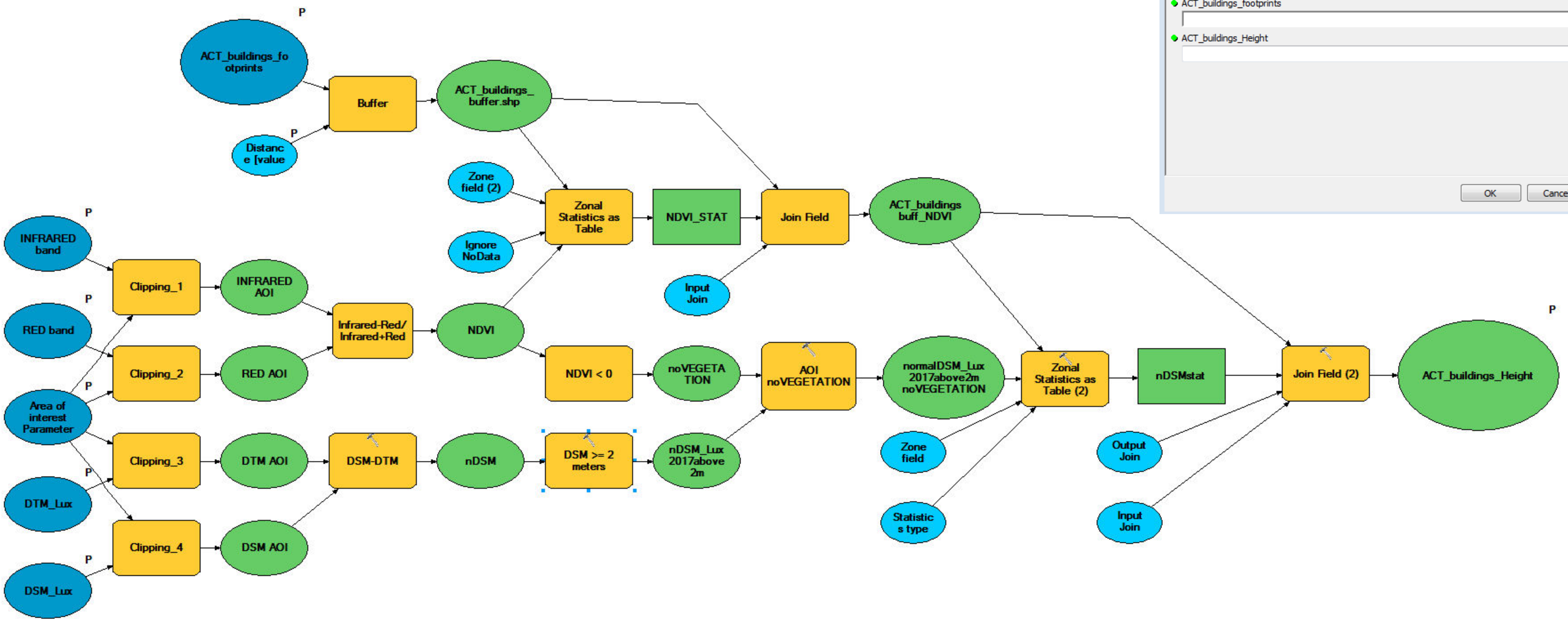
- Housing
- Congestion, transport problems

Vertical densification permit taller, denser structures—will increase supply and cause prices to fall, which will then make housing (and expensive areas/cities) more affordable.

While promoting green spaces for the well-being of citizens

Lux Smart Growth (ARC VIEW 3.3 Model builder)





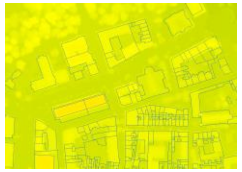
Result

- Hmax, Hmean

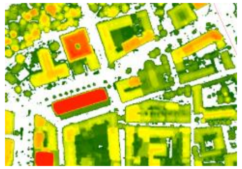
OID	Quartier	Hmax	Hmean
0	Basse Pétrusse	19,58	15,2
18	Ville Haute	18,56	14,92
10	Hollerich	14,23	11,09
11	Limpertsberg	13,64	10,59
8	Grund	13,98	10,49
12	Merl-Nord	12,97	10,34
13	Merl-Sud	13,09	10,3
14	Neudorf	12,24	9,5
2	Bonnevoie	12,1	9,46
15	Pfaffenthal	12,15	9,22
7	Gasperich	11,44	8,94
1	Beggen	11,57	8,82
17	Rollingergrund	10,96	8,54
19	Weimerskirch	10,97	8,47
5	Dommeldange	11,1	8,29
4	Clausen	10,83	8,15
3	Cessange	10,53	8,12
6	Eich	10,78	8,12
16	Pulvermuehl	10,86	7,71
9	Hamm	10,1	7,64

Data

DTM



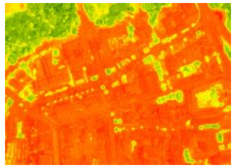
DSM



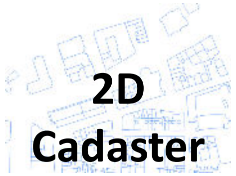
nDSM

InfraRED

RED

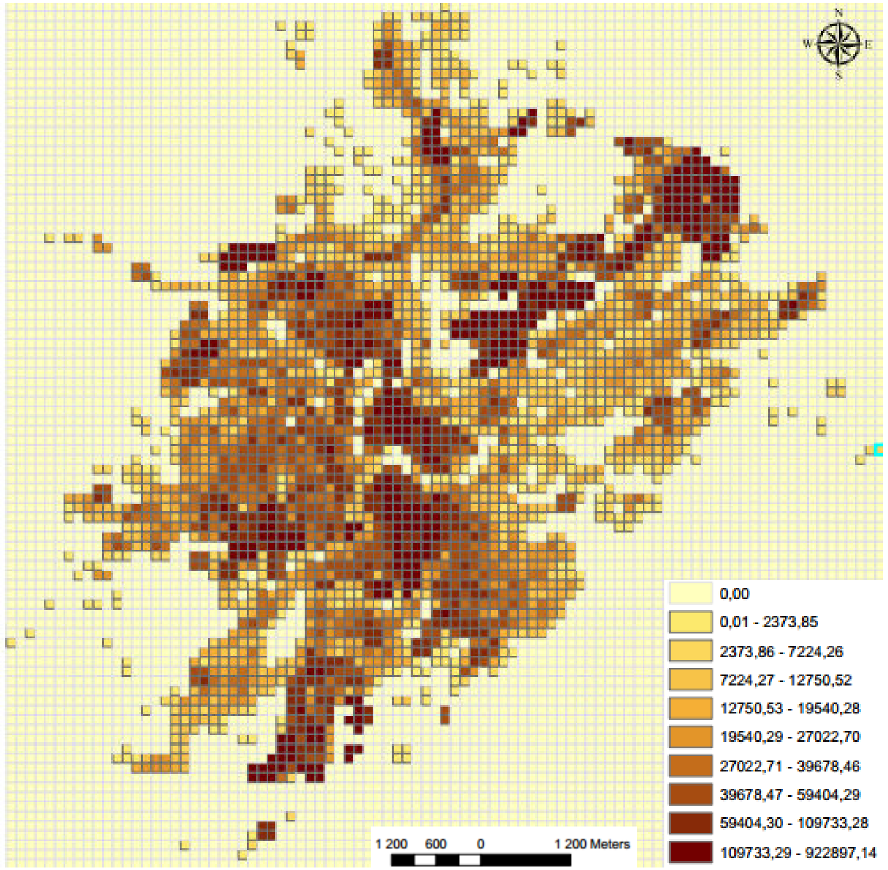


NDVI

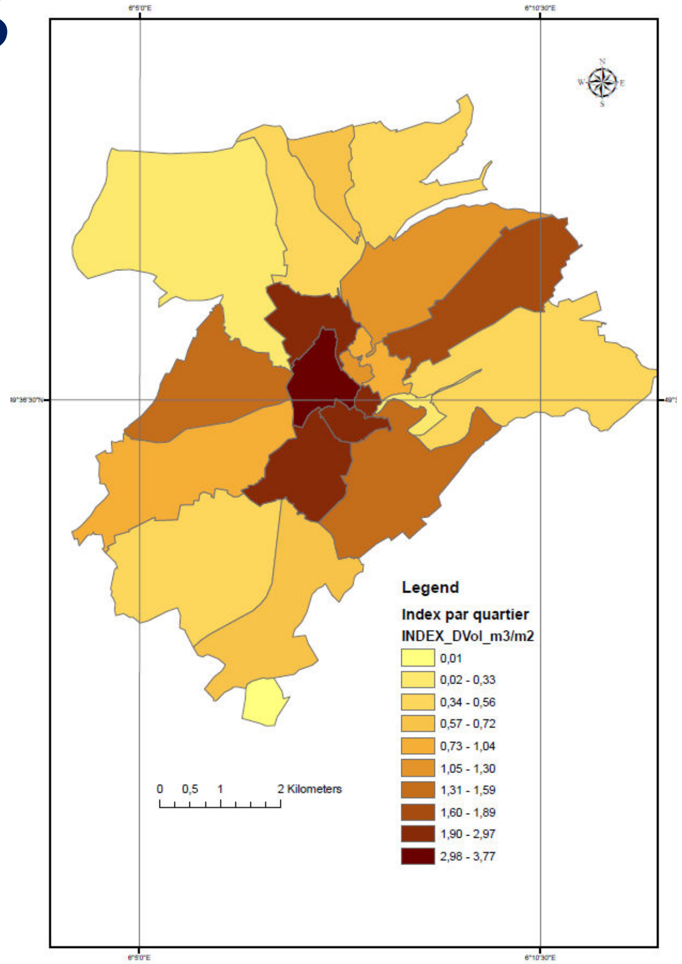


2D Cadaster

Urban volumetry index in Luxembourg city



Volumetric density (km3)



Distribution of urban volumetry index among quartiers

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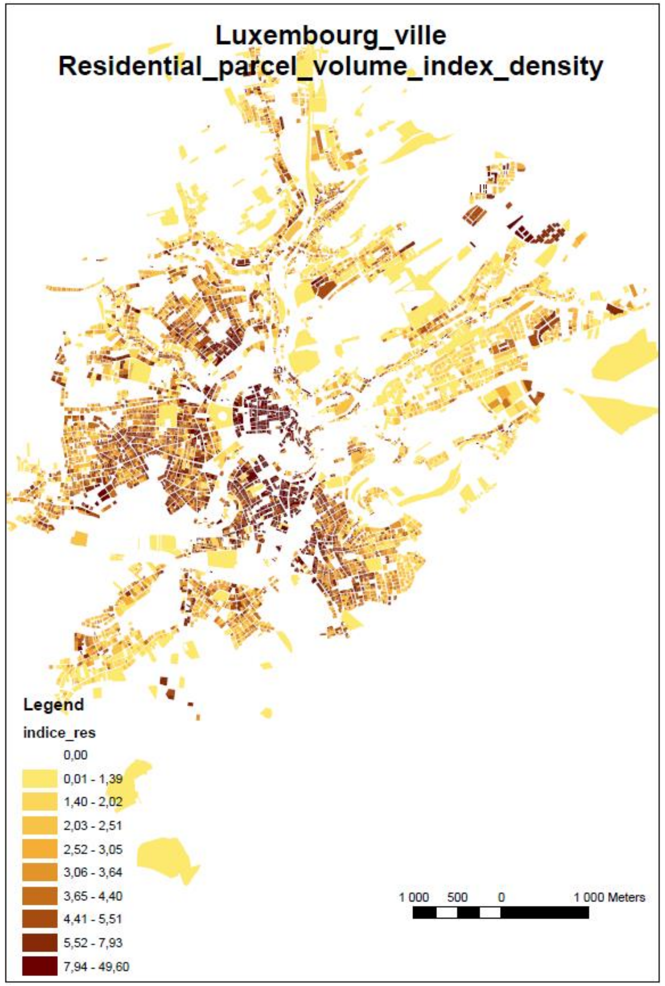
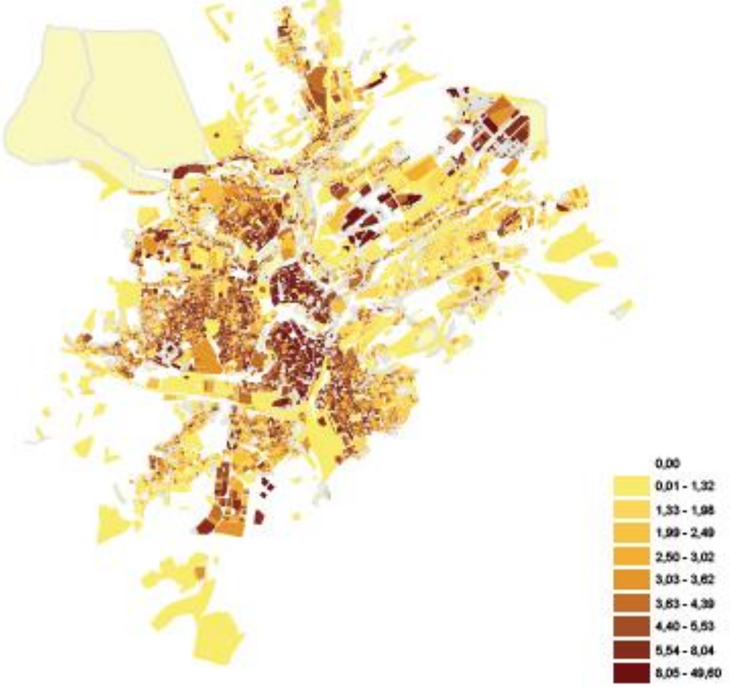
Urban volumetry index (m3/m2):
Sum(Hi * Si) / S; i = 1... N


Luxembourg_ville
Residential_parcel_volume_index_density
Legend
indice_res
0,00
0,01 - 1,39
1,40 - 2,02
2,03 - 2,51
2,52 - 3,05
3,06 - 3,64
3,65 - 4,40
4,41 - 5,51
5,52 - 7,93
7,94 - 49,60
1 000 500 0 1 000 Meters


0,00
0,01 - 1,32
1,33 - 1,98
1,99 - 2,49
2,50 - 3,02
3,03 - 3,62
3,63 - 4,39
4,40 - 5,53
5,54 - 8,04
8,05 - 49,60

Density Index

- The **Density Index** is a measure of how built-up an area is. Higher numbers indicate that an area is more built-up.
- It is calculated by dividing the total building volume in m^3 by the total land area in m^2.