Application of a green infrastructure typology and airborne remote sensing to classify and map urban vegetation for climate adaptation

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Application of a green infrastructure typology and airborne remote sensing to classify and map urban vegetation for climate adaptation

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Background

Systematic review of 85 articles* shows:

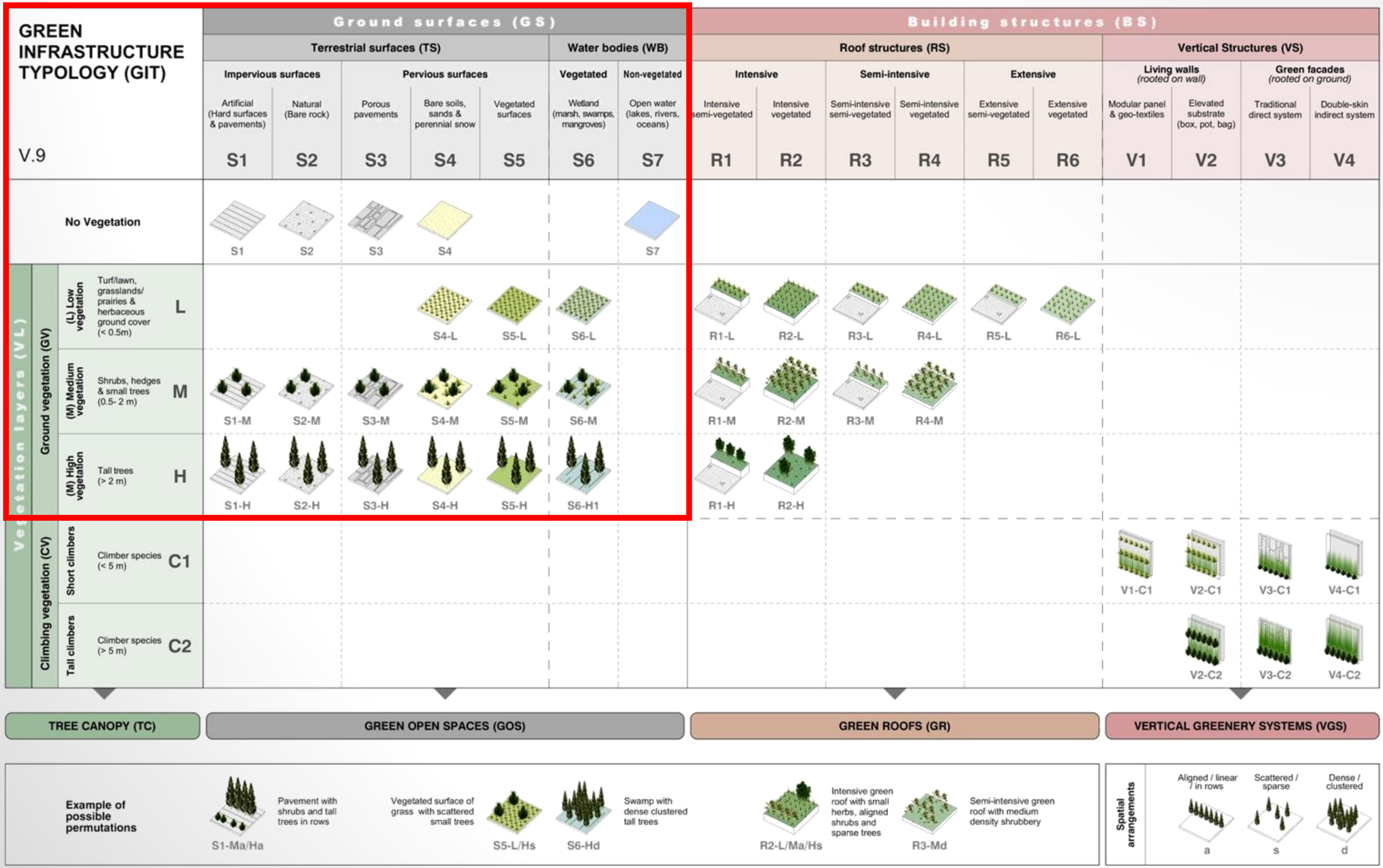
- **No common protocols & standards** to describe, compare and report the evidence of the ecosystem services of GI > *Need for a typology*
- **Spatial heterogeneity** precludes a clear identification of typologies
- **GI includes a combination** of natural, semi-natural and engineered elements.
- Current **classifications (i.e. LULC)** still inadequate > highly dependent on land-uses
- **Aspects** to consider to classify GI:

(1) Multi-functionality (trees vs parks)
(2) Spatial heterogeneity (what is GI?)
(green-to-grey continuum)
(3) Interconnectivity (boundaries)

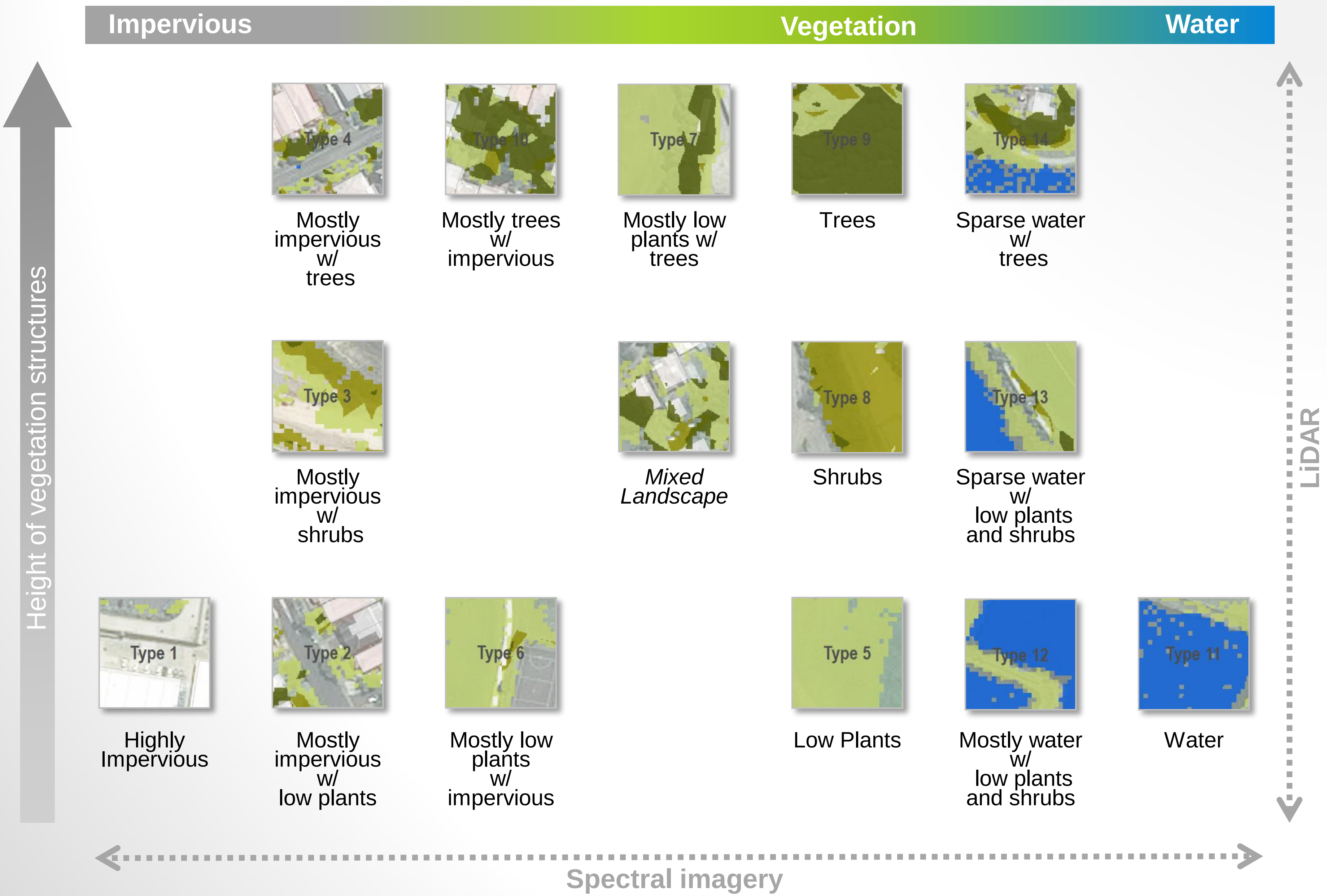
* Bartesaghi Koc, C. et al (*in press*).

Proposed GIT matrix

After Bartesaghi Koc, C. et al. (2016a, *in press*)



Refined GIT



Impervious
Vegetation
Water
Height of vegetation structures
LiDAR
Spectral imagery
Type 4
Mostly impervious w/ trees
Type 10
Mostly trees w/ impervious
Type 7
Mostly low plants w/ trees
Type 9
Trees
Type 14
Sparse water w/ trees
Type 3
Mostly impervious w/ shrubs
Mixed Landscape
Type 8
Shrubs
Type 13
Sparse water w/ low plants and shrubs
Type 1
Highly Impervious
Type 2
Mostly impervious w/ low plants
Type 6
Mostly low plants w/ impervious
Type 5
Low Plants
Type 12
Mostly water w/ low plants and shrubs
Type 11
Water

GIT – *Classification values*

Based on Irger (2014) and Stewart & Oke. (2012)

CODE	TYPE	Impervious fraction	High Veg fraction	Med veg fraction	Low Veg fraction	Water fraction
Type 1	Highly impervious	>= 80	<= 20	<= 20	<= 20	<= 20
Type 2	Mostly impervious with low plants	>=40 - < 80	<= 10	<= 10	< 50	<= 10
Type 3	Mostly impervious with shrubs	>=40 - < 80	<= 10	>= 10	< 50	<= 10
Type 4	Mostly impervious with trees	>=40 - < 80	> 10 - <= 40	<= 25	< 40	<= 10
Type 5	Low Plants	<= 20	<= 20	<= 20	>= 80	<= 20
Type 6	Mostly low plants with impervious	< 50	<= 10	<= 10	>= 50 - < 80	<= 10
Type 7	Mostly low plants with trees	< 50	> 10 - <= 50	<= 25	>= 40 - < 80	<= 10
Type 8	Shrubs	< 40	<= 20	>= 50	< 50	<= 20
Type 9	Trees	<= 10	>= 50	<= 10	< 50	<= 10
Type 10	Mostly Trees with impervious	>= 20	40 - 80	<= 10	< 50	<= 10
Type 11	Water	<= 20	<= 20	<= 20	<= 20	>= 75
Type 12	Mostly water with low plants and shrubs	< 50	<= 10	< 50	< 60	>= 50 - < 75
Type 13	Sparse water with low plants and shrubs	< 50	<= 10	< 50	>= 10	>= 10 - < 50
Type 14	Sparse water with trees	< 50	>= 10	< 50	>= 10	>= 10 - < 50
Type 15	Mixed landscape					

Results – *surface fractions & NDVI*

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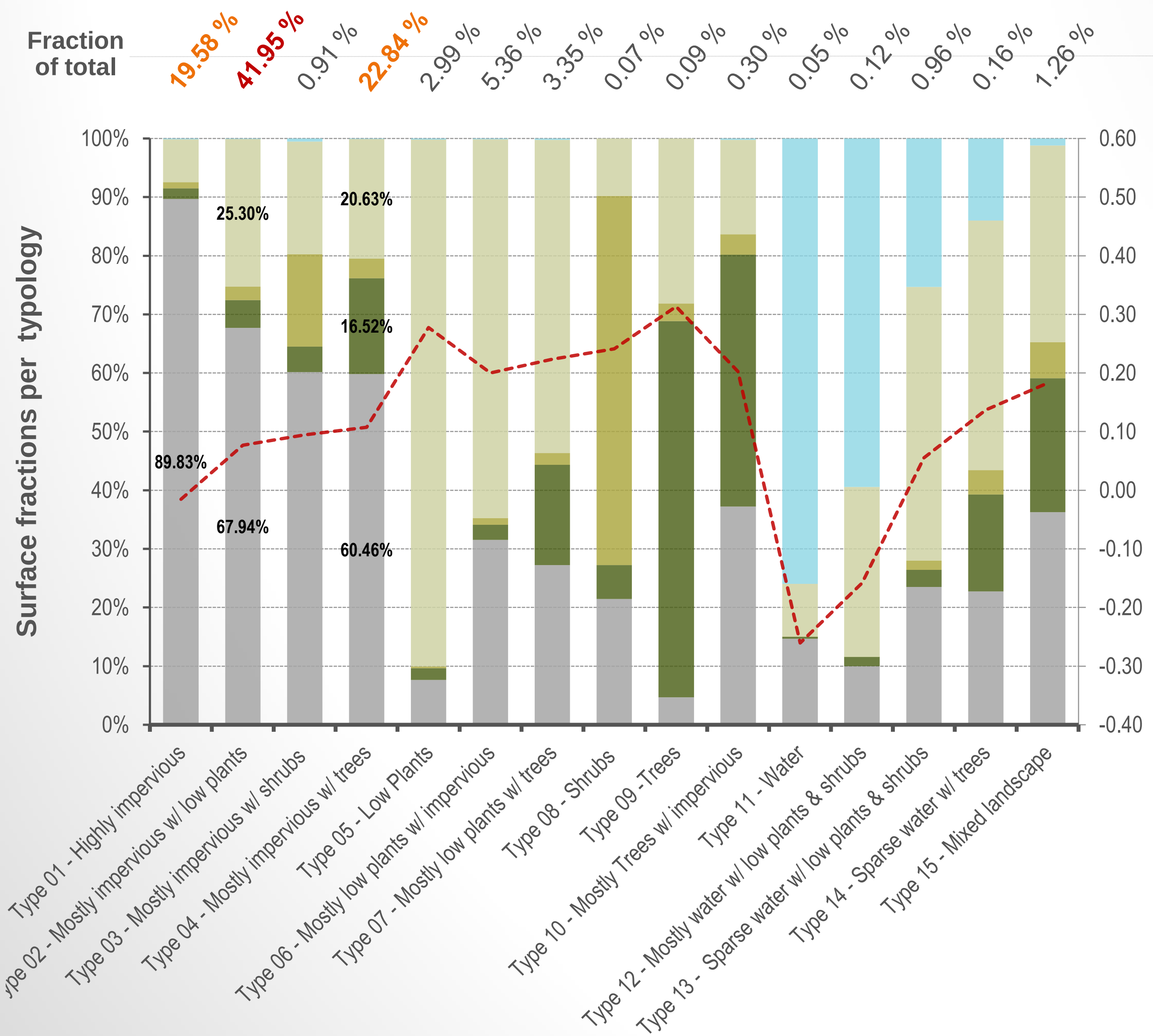
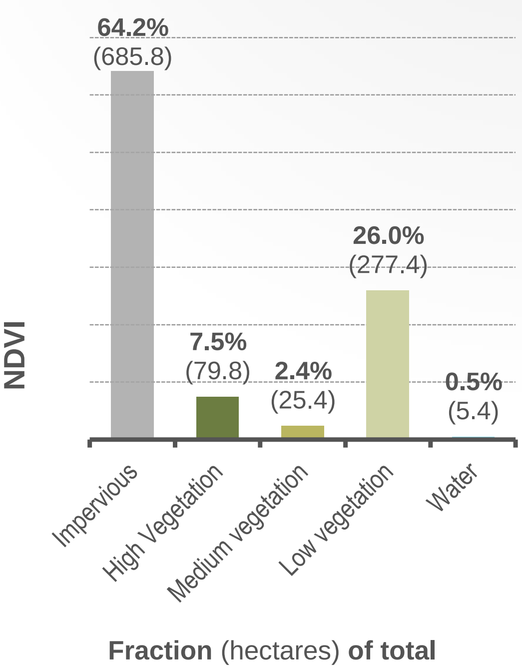
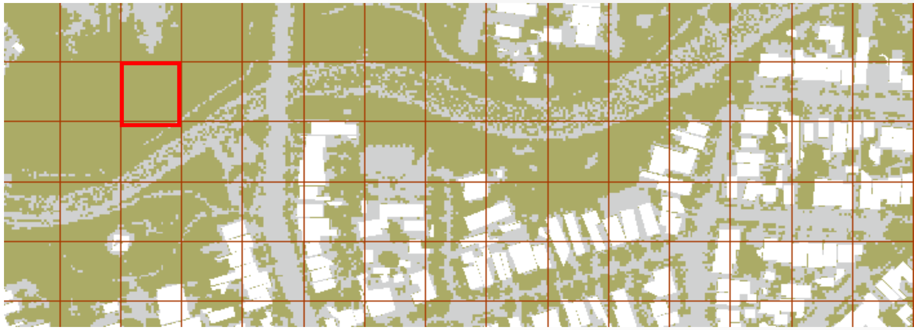


TOTAL - PILOT STUDY:
4274 grids → 1068.5 ha

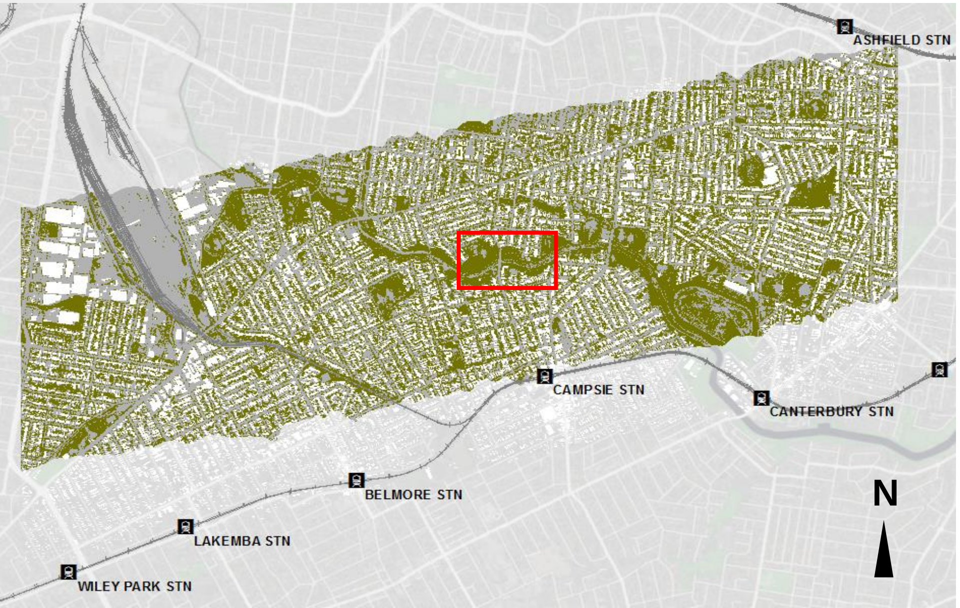


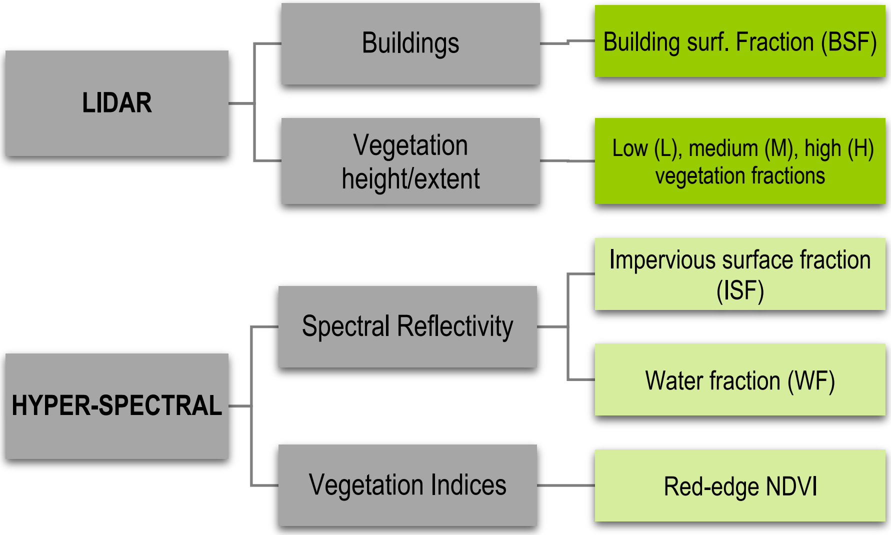
Water
Low vegetation
Medium vegetation
High Vegetation
Impervious
Mean NDVI

Method – *Pilot study and datasets*

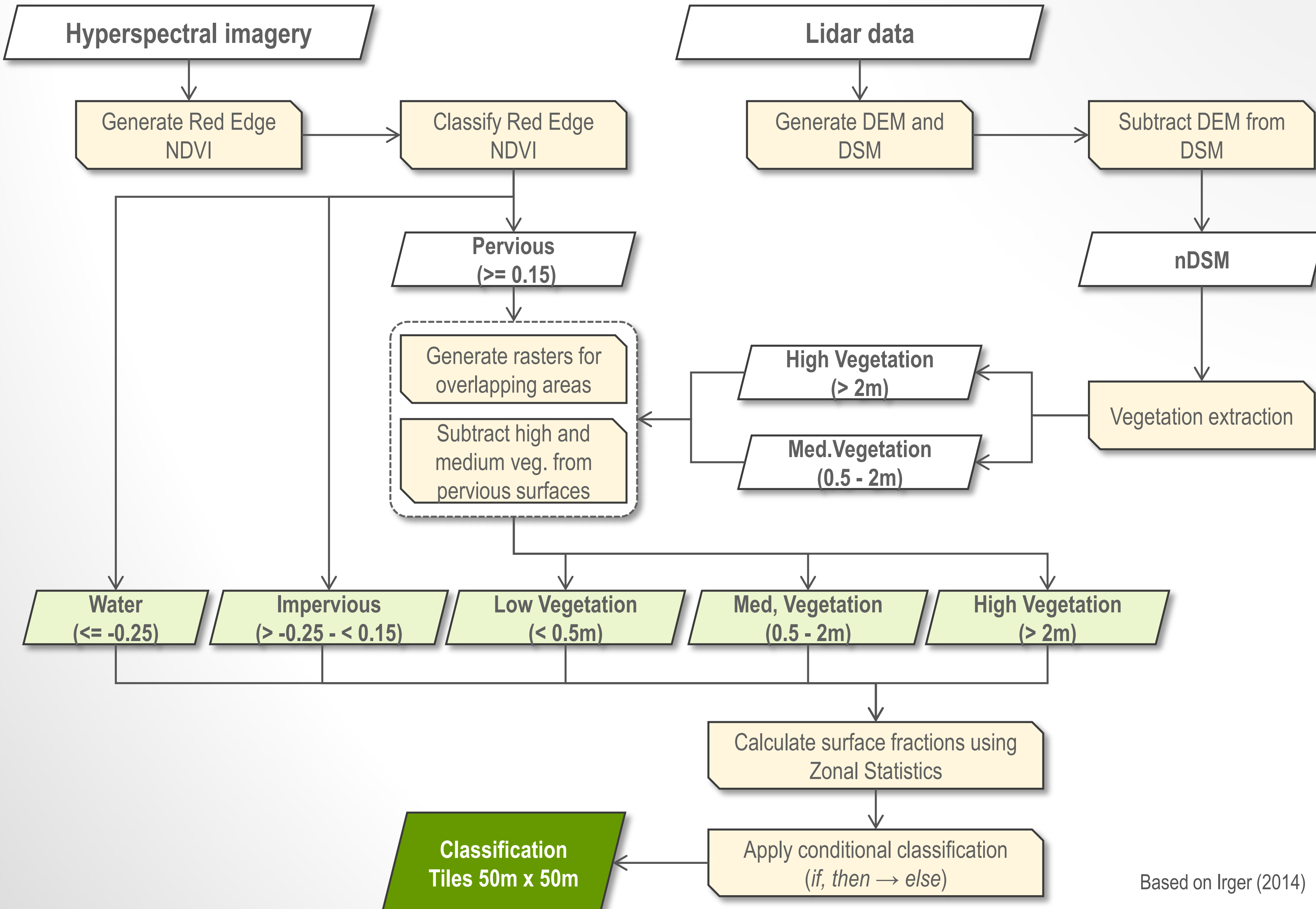


- Winter data (August 6, 2012)
- 50 x 50 m analysis grid
- Imagery resolution:
  - Lidar 0.8 pts/sqm
  - Hyperspectral 2m
  - Everything resampled to 0.5m





Method – *GIS-based workflow*



Based on Irger (2014)

GIT – *classification results*

Findings – *Typology applicability*

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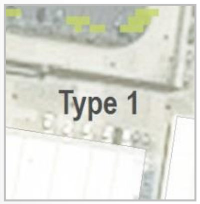
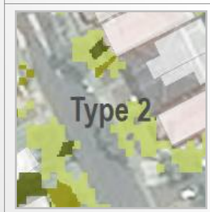
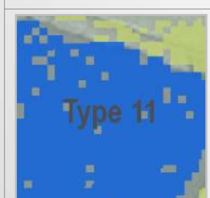
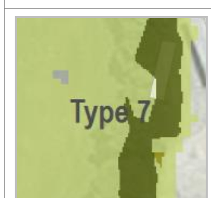
Highly impervious		
# Grids: 837	Properties	Mean values
	1. NDVI	- 0.015
	2. Impervious fraction	89.83 %
	3. Low vegetation fraction	7.32 %
	4. Medium vegetation fraction	1.05 %
	5. High vegetation fraction	1.80 %
	6. Water fraction	0.16 %

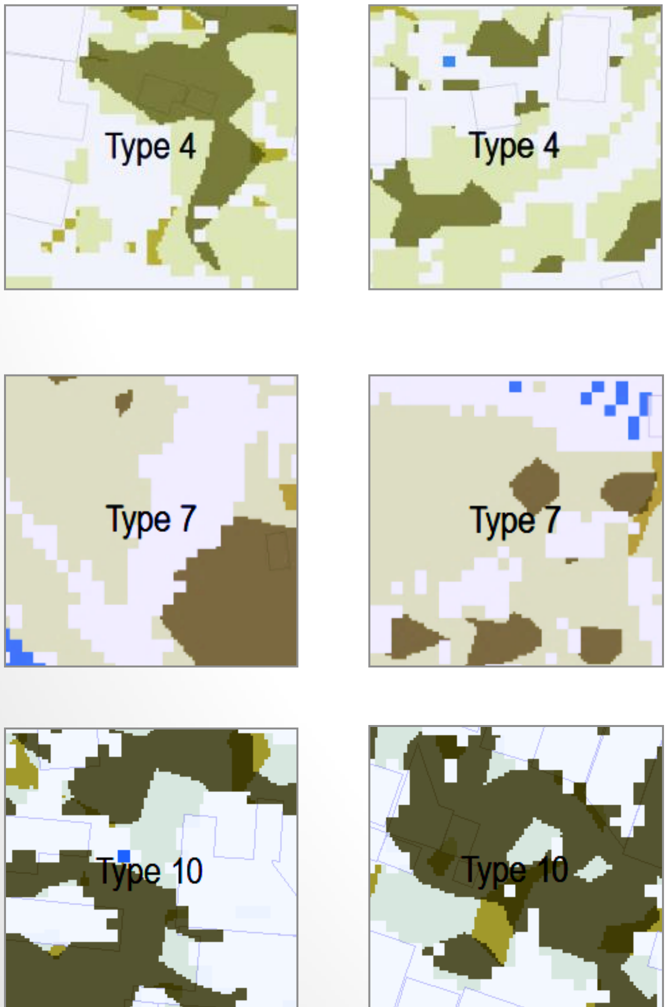
Mostly impervious with low plants		
# Grids: 1793	Properties	Mean values
	1. NDVI	0.077
	2. Impervious fraction	67.94 %
	3. Low vegetation fraction	25.30 %
	4. Medium vegetation fraction	2.29 %
	5. High vegetation fraction	4.72 %
	6. Water fraction	0.09 %

Water		
# Grids: 2	Properties	Mean values
	1. NDVI	-0.261
	2. Impervious fraction	14.65 %
	3. Low vegetation fraction	9.00 %
	4. Medium vegetation fraction	0.02 %
	5. High vegetation fraction	0.37 %
	6. Water fraction	75.98 %

- Very few number of unclassified grids (*n=54* ~1.5%).
- Strong correlation between typologies' characteristics (surface fractions) and mean NDVI values.
- Impervious surfaces were the largest by far across the whole pilot study.
- The most numerous typologies combined impervious surfaces with low plants and few trees.
- Impervious surfaces combined building and ground surfaces; future work could consider their differentiation.

Mostly low plants with trees		
# Grids: 143	Properties	Mean values
	1. NDVI	0.223
	2. Impervious fraction	27.36 %
	3. Low vegetation fraction	53.68 %
	4. Medium vegetation fraction	2.00 %
	5. High vegetation fraction	17.16 %
	6. Water fraction	0.24 %

Findings – *Typology applicability*



- Estimation of surface cover fractions results insufficient to classify tree canopy distribution → Need for differentiation between clustered and sparse arrangements in typologies 4, 7, 9, 10 & 14.
- LiDAR point cloud density and vegetation phenology have huge impacts on the accuracy and quality of vegetation / buildings extraction that potentially may lead to error (under-/overestimations).
- Red Edge NDVI thresholds should be further studied.
- The typology can be used for multiple purposes, though it is especially aimed for spatial and performance analyses (quantitative and qualitative), and for inventorying conditions to prioritise GI interventions.

Conclusions and future work

- A standardised classification scheme (conventions and protocols) to estimate the vegetation cover of large areas with high resolution and accuracy → Potential use to inform and propose climate change adaptation/mitigation strategies.

- The typology facilitates the reporting of the current state of environment, as well as Inter-site & inter-typology comparison.

- Other indicators can be estimated and assigned to each typology (i.e. biomass, carbon sequestrations, evapotranspiration, surface temperature, etc.)

- Next steps:
  - To incorporate spatial metrics to distinguish different arrangement of trees.

  - To consider urban morphology aspects by applying the GIT along with the local climate zones (LCZ) to assess the thermal profiles of GI.

  - To test different grid sizes, NDVI thresholds and LiDAR extraction parameters.

Image: EEA (2013). Building a green infrastructure for Europe.

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Thank you for your attention

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