USING LOCAL CLIMATE ZONES METHODOLOGY TO ASSESS VULNERABILITY AND POTENTIAL RISK IN URBAN ECOSYSTEMS AT A FRAMEWORK OF CLIMATE CHANGE

ICUC - 10

Joan Gilabert[1,2], María Carmen Llasat[1] and Jordi Corbera[2]

(1) GAMA Team, Dept. Applied Physics, University of Barcelona; (2) Institute Cartographic and Geological of Catalonia

The **goal** of this study is to analyse the vulnerability and potential risk on urban heat island (UHI) through Local Climate Zones (LCZ) as an indicator of exposure to heat. Sensitivity is associated an indicator based on demography and age. The cartography of these indicators over the region allows to characterize the most vulnerable areas with a major resolution than all the works made until now in Barcelona.

Study design

1. Characterize UHI in Barcelona
2. Map the study area into LCZ
3. Analyze the vulnerability through the heat vulnerability indexes (HVI)
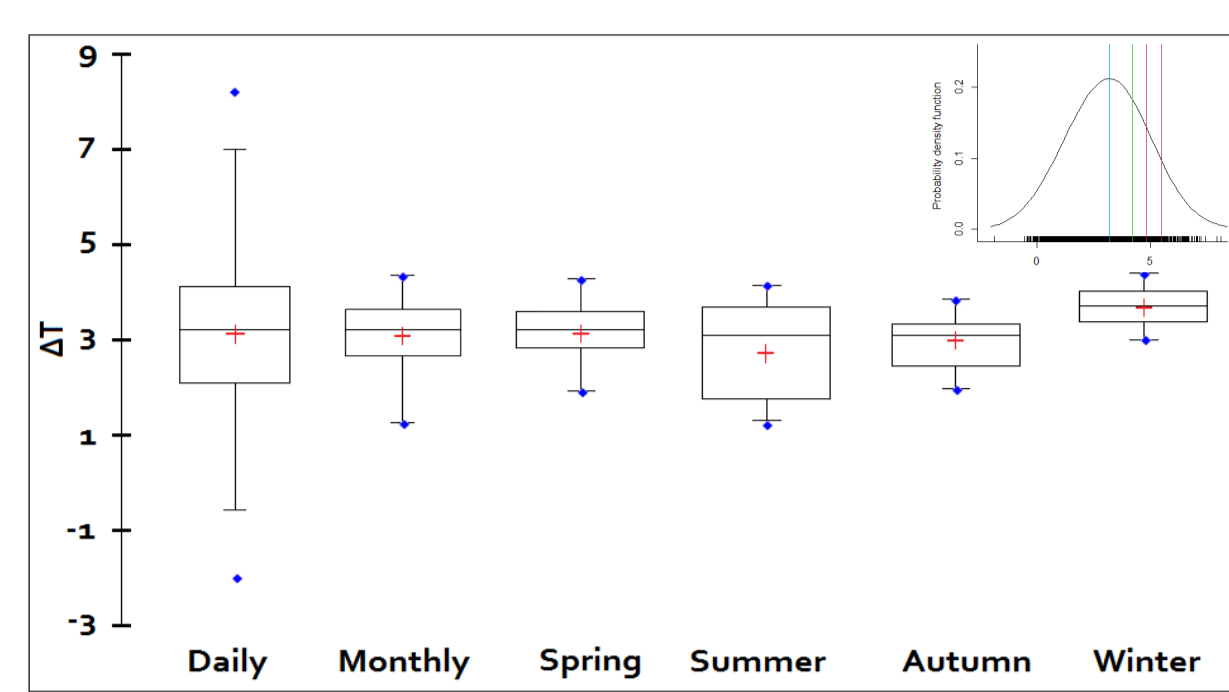4. Evaluate the potential risk (UHI + HVI)

Fig 1. Boxplots of $\Delta_{Tmin\ rural-Tmin\ urban}$ daily, monthly and seasonally of MAB.

1- UHI in Barcelona

In order to characterize the hazard, we perform a classic analysis comparing the daily Tmin between an urban weather station (1) and a peri-urban weather station (2) (fig 10/11) in Barcelona over a 7 years period (2008-2015). To classify the level of hazard of UHI a normal distribution has been applied to this differences of temperatures. Afterwards, has been combined with vulnerability scenarios to obtain a matrix of risk (table 2).

2- Mapping the study area

Layer	Information	GSD	Year	Format	Use
Urban Atlas	20 categories of urban fabric	50m	2012	Vector	LCZ map
LCLU-Cat	241 categories of land cover	0.25m	2010	Vector	LCZ map
Building Heights	Height (m)	0.5m	2014	Vector	LCZ map
Ortophoto	Mosaic of aerial photos	0.25m	2016	Raster	Validate
Population	Population by ages	100m	2016	Vector	Validate

Table 1. Material and data used to create LCZ maps.
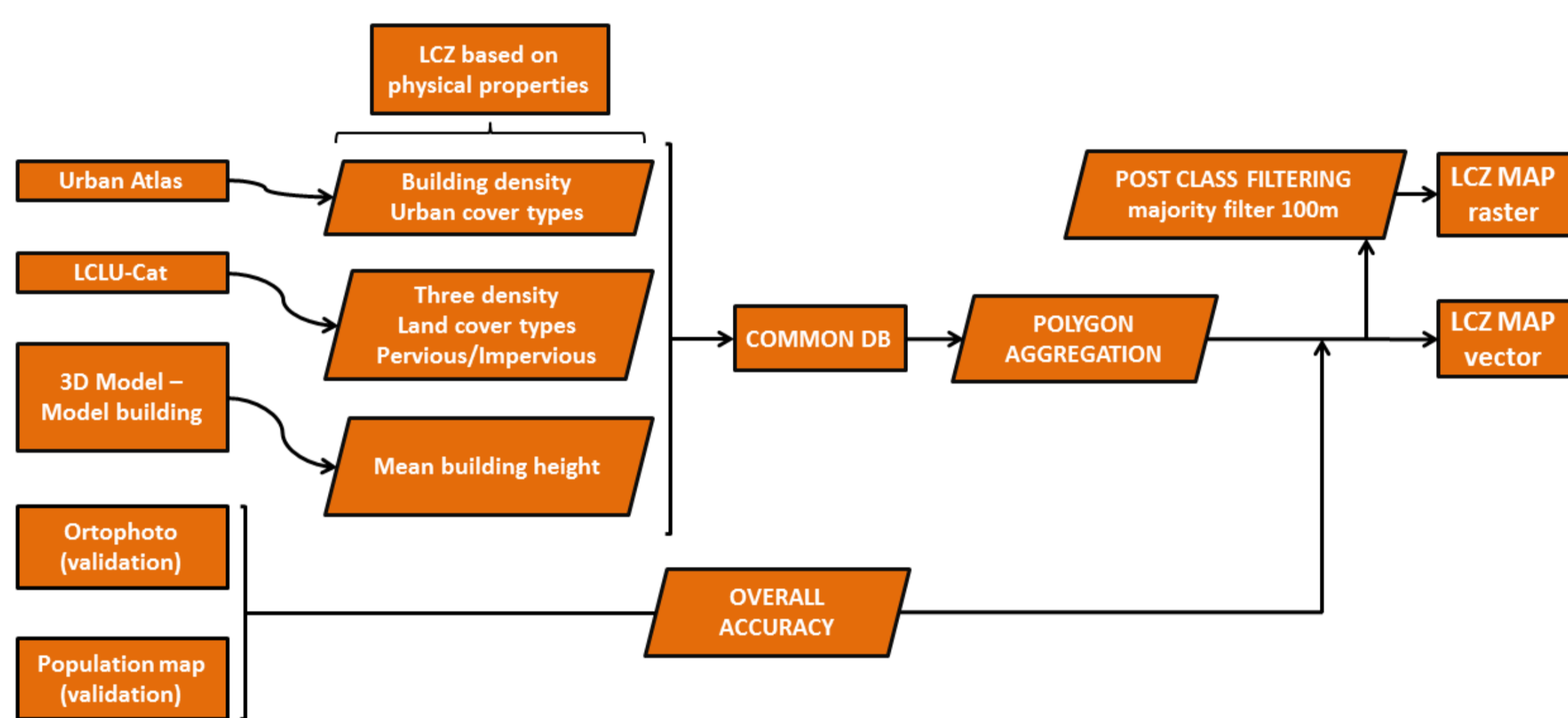

Fig 2. Workflow process of GIS – LCZ map.
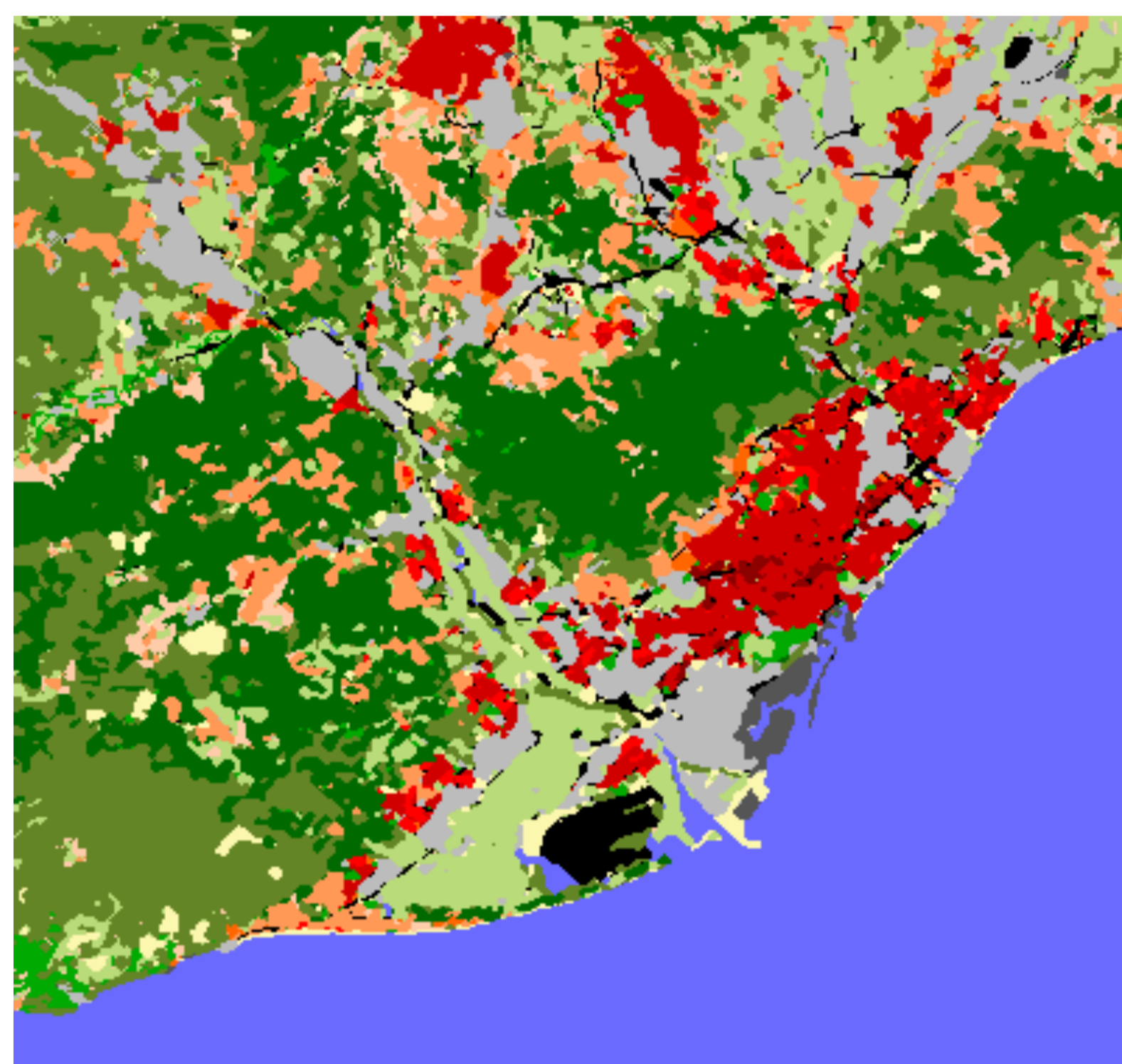
Barcelona Metropolitan Area (raster approach)

Fig 3. LCZ – GIS raster map 100x100m of Barcelona Metropolitan Area. Input for UrbClim Model.
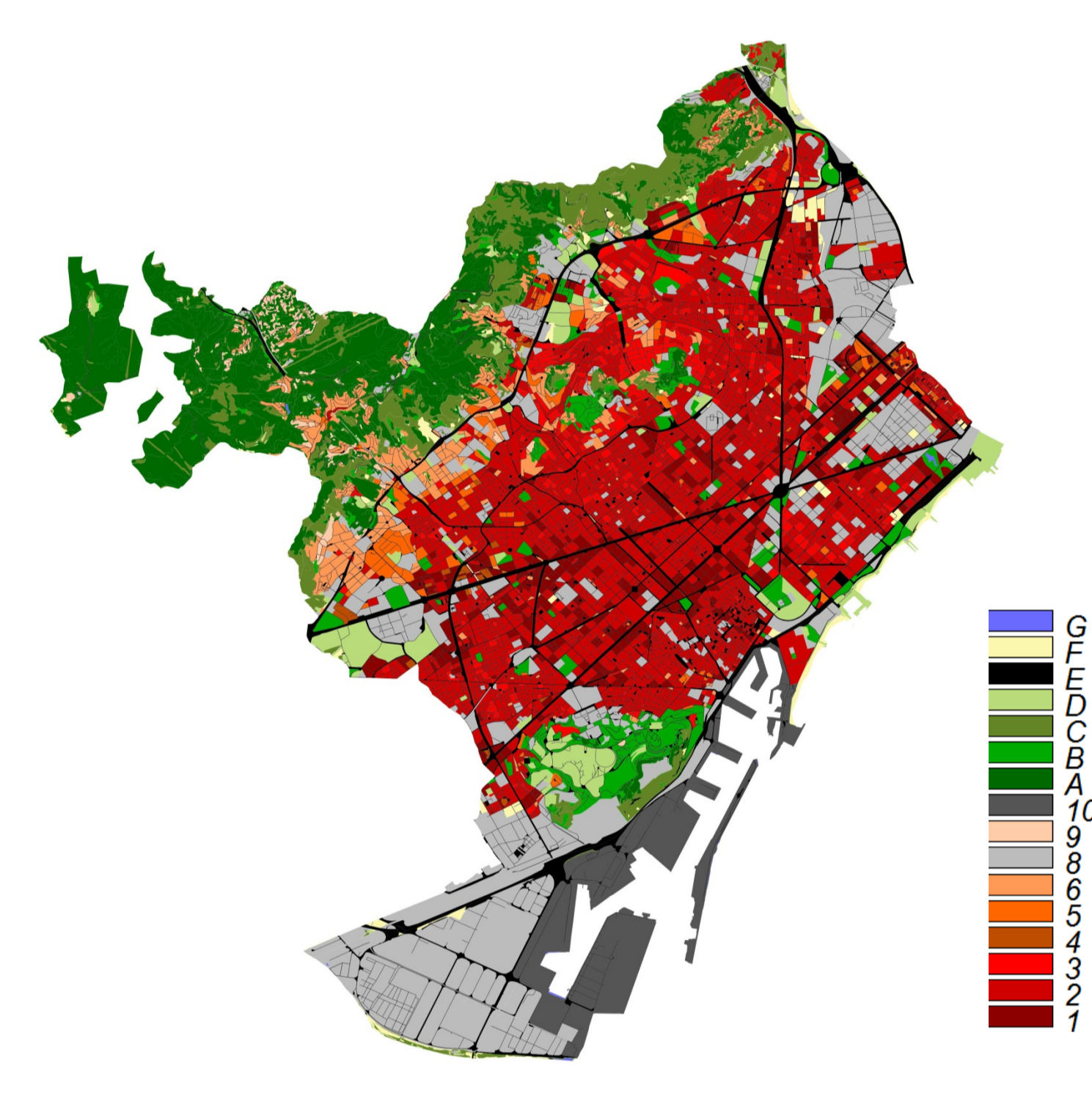
Barcelona (vector approach)

Fig. 4 LCZ – GIS vector map of Barcelona with a multiresolution (2x2m to 50x50m) to estimate the vulnerability at high resolution.

3- Vulnerability heat indexes

$$\text{Vulnerability} \begin{cases} \text{exposure to heat: Local Climate Zones (A)} \\ \text{sensitivity} - \text{demography} - \text{age (B)} \end{cases}$$

Indexes to evaluate the vulnerability to UHI:

A) Urban Climate Vulnerability Index (UCVI)

P_{ij}

Sky View Factor
Aspect Ratio
Building Surface Fraction
Impervious Surface
Pervious Surface
Height of Roughness
Terrain Roughness Class

Surface admittance
Surface Albedo
Anthropogenic heat output

LCZ_i → $UCVI_{LCZ_i}$

1) $P_n = \left.\dfrac{P_{ij}}{A_j}\right|_{i=1..17}$

2) $A_j = \left.\max(P_j)\right|_{j=1..10}$

3) $LCZ_i = \sum_{j=1}^{10} P_{n\ ij}$
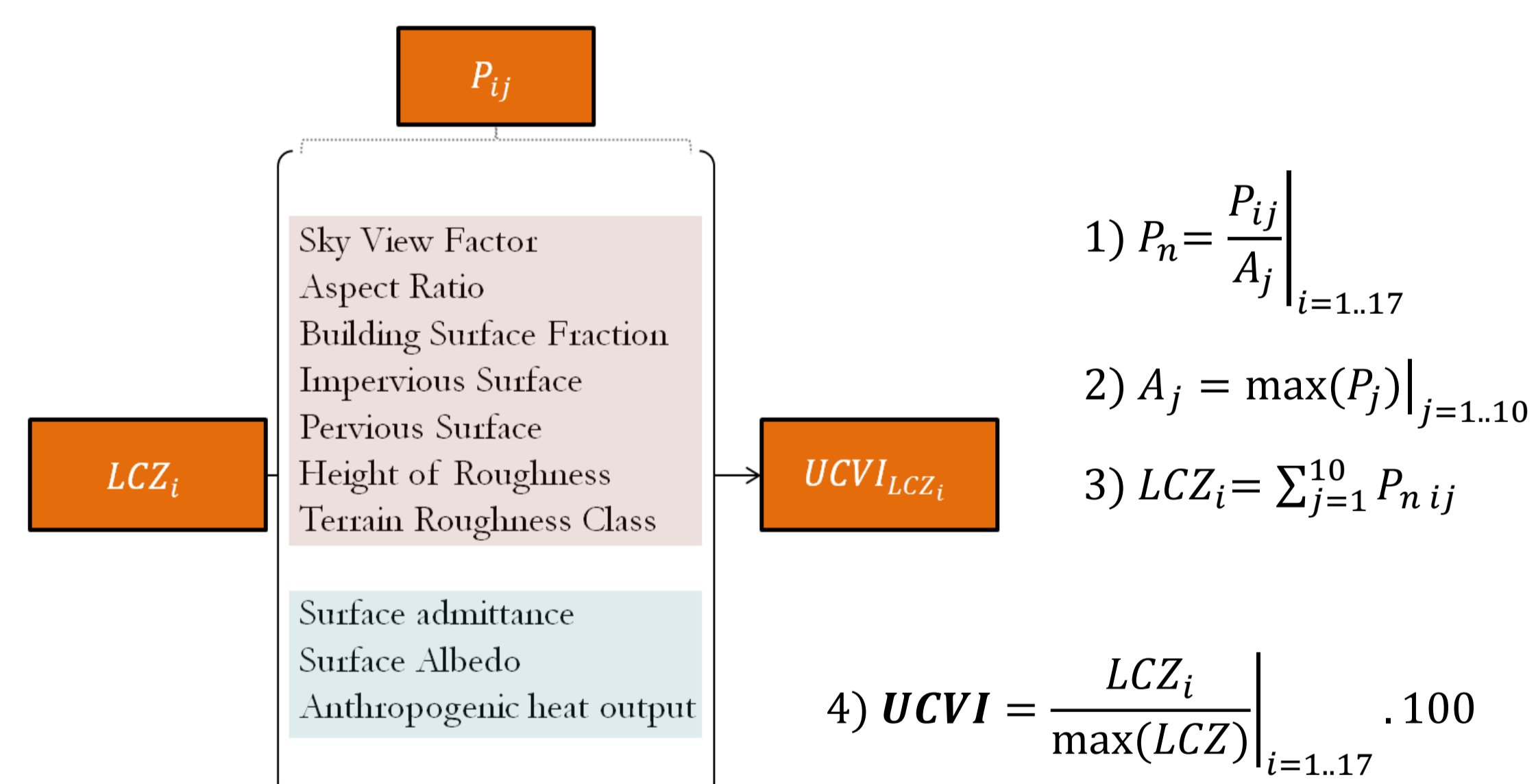
4) $UCVI = \left.\dfrac{LCZ_i}{\max(LCZ)}\right|_{i=1..17} \cdot 100$

Fig 5. The combination of these 10 parameters creates 17 LCZ, (Stewart and Oke, 2012).
parameters 1 and 5, the inverse is taken.

B) Climate Vulnerability People (CVP)
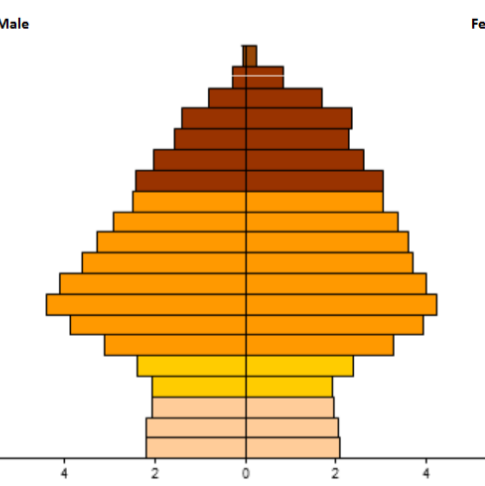
$$CVP = \dfrac{P_{>64} + P_{<2}}{P_{total}} \cdot 100$$

Fig 6. Pyramid of population in Barcelona 2015. It can observe an ageing population, consequently sensible population.

COUPLING UCVI + CVP:

- Exploratory data analysis (EDA)
- K-means cluster analysis
- Thresholds based on extremes

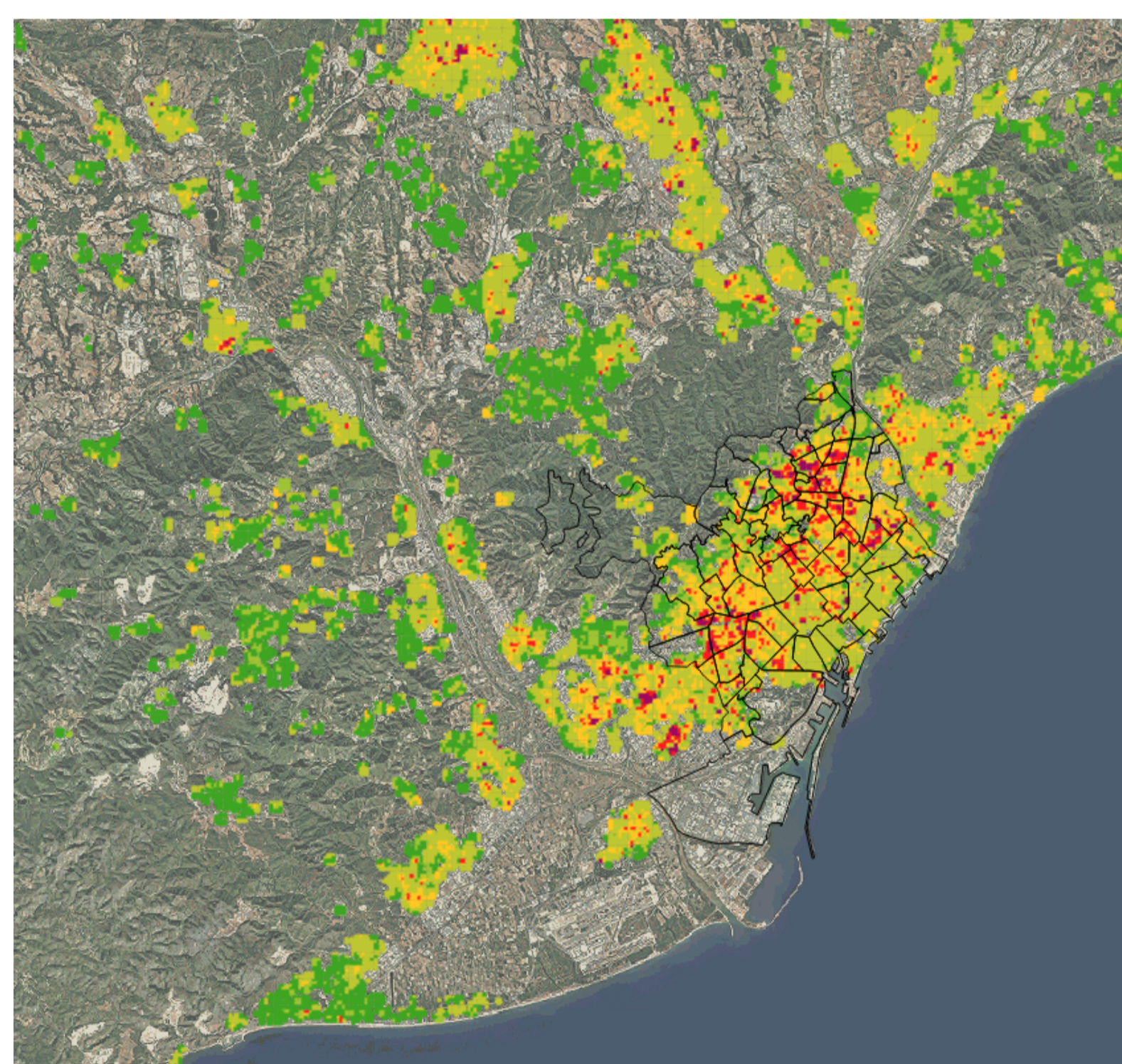Fig 7. Conceptual scheme of different CVP/ UCVI scenarios.

Fig 8. LCZ – GIS raster vulnerability map 100x100m of Barcelona Metropolitan Area, based on a scenario (UCVI/CVP) for each pixel.

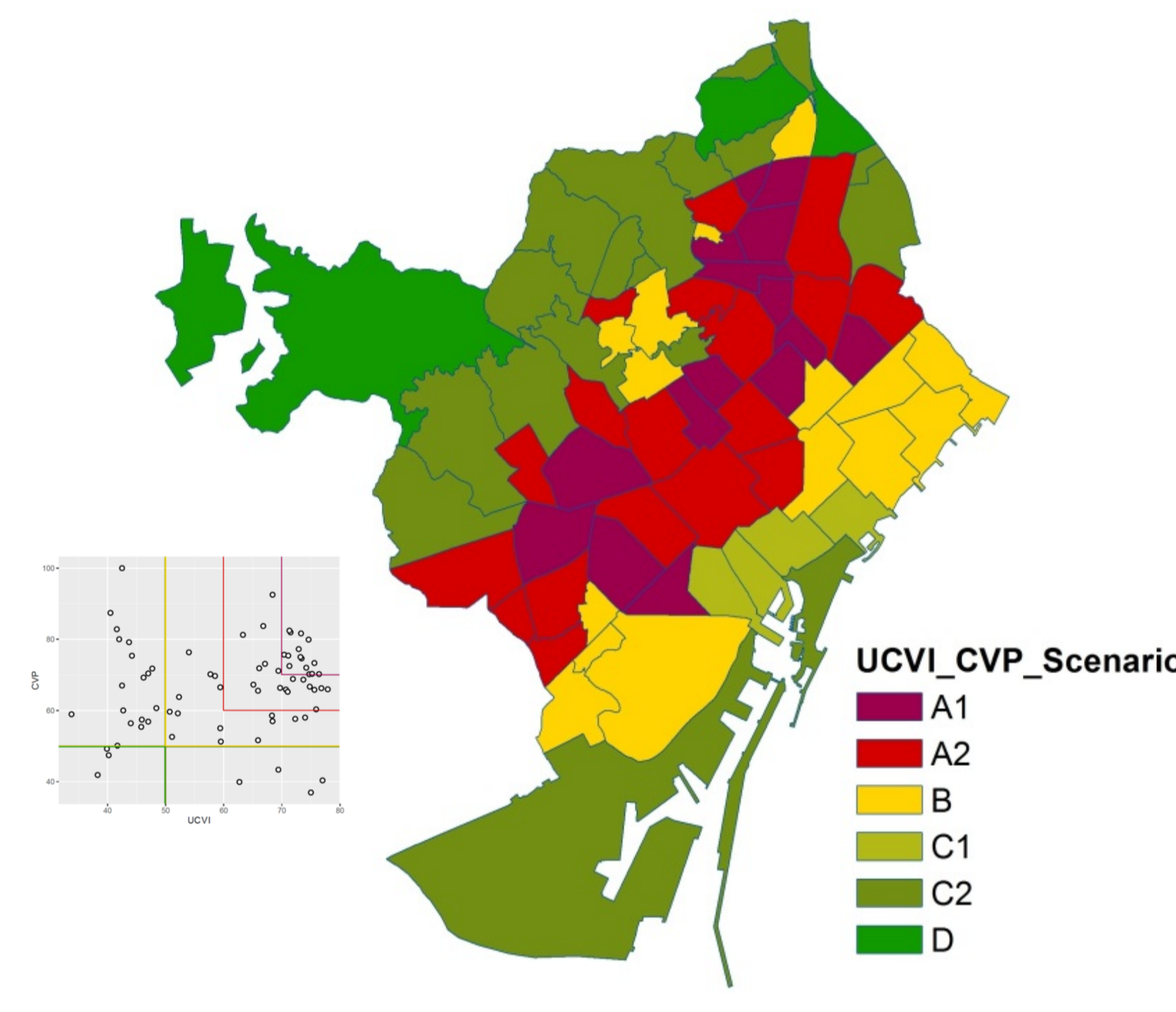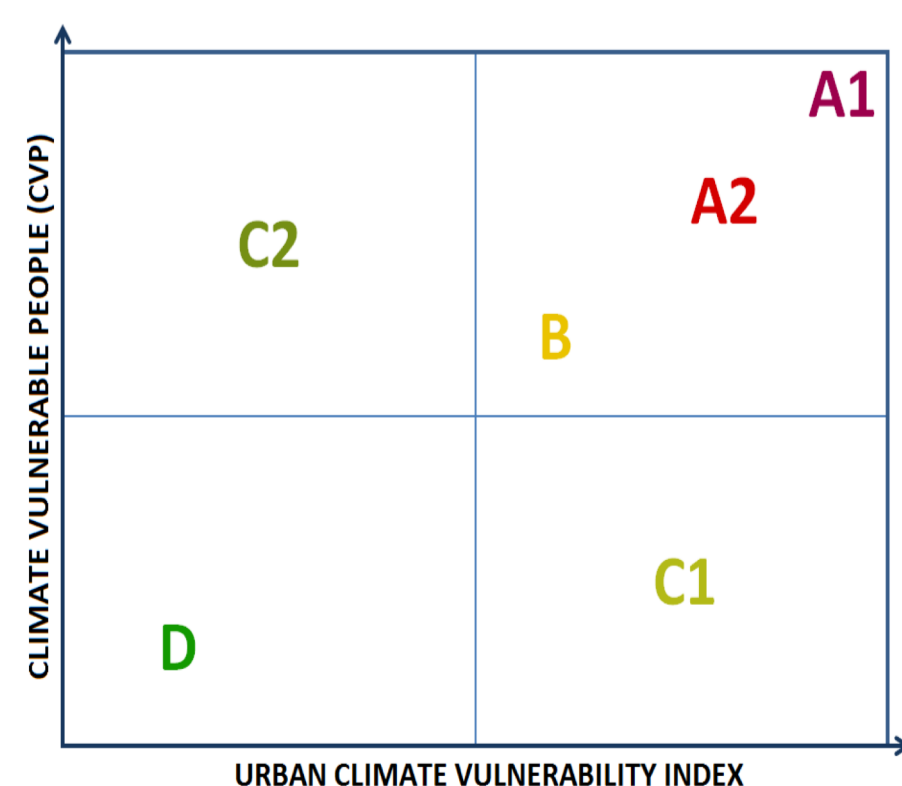Fig 9. LCZ- GIS vector vulnerability map, based on an average scenario (UCVI/CVP) for each neighborhood.

UCVI_CVP_Scenario
A1
A2
B
C1
C2
D

4- Evaluate potential risk

RISK = *Vulnerability* x *Hazard*
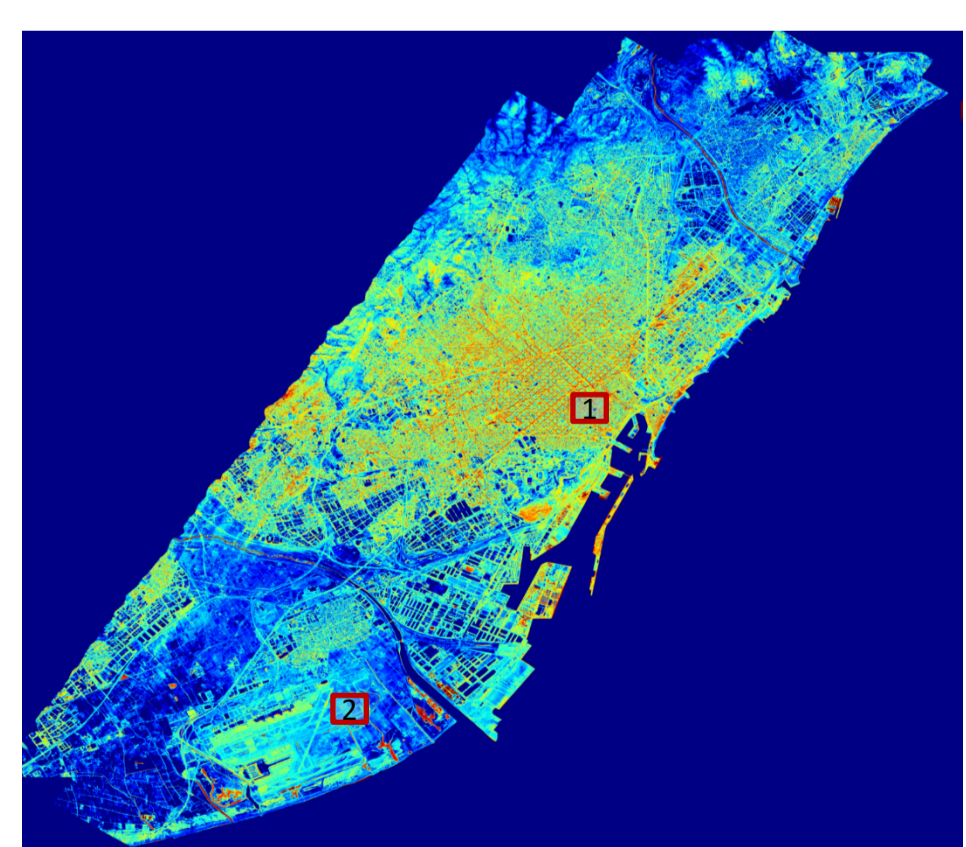
Fig 10. Mosaic of UHI over Barcelona and surroundings captured by TASI (GSD=2m) for a specific night.

1- Raval Weather Station – Urban
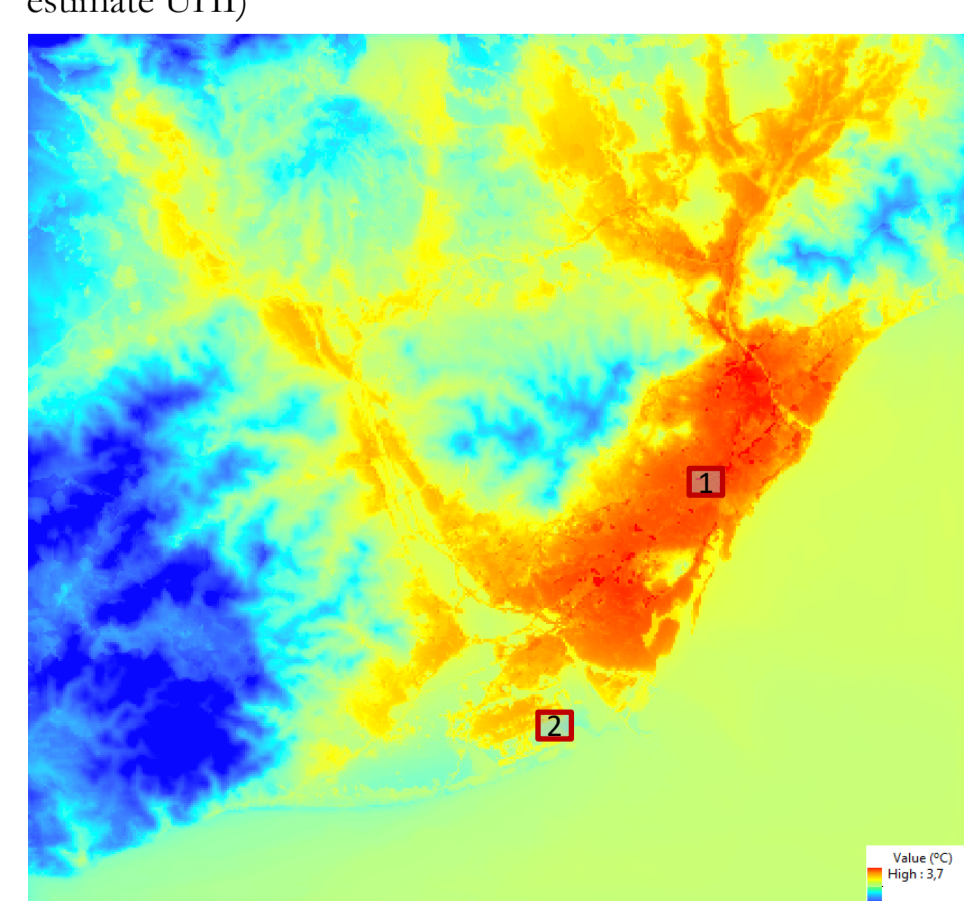2- El Prat Weather Station – Peri-urban (reference area to estimate UHI)

Fig 11. UHI corresponding to the difference between each pixel (100x100m) and 2. From JJA Tmean P95 (2010-2016) ERA5 – Run with UrbClim Model (output).

	D	C	B	A2	A1
≤ Q₂	2	3	4	5	6
Q₃	3	4	5	6	7
> Q₃	4	5	6	7	8
> P90	5	6	7	8	9
>P95	6	7	8	9	10

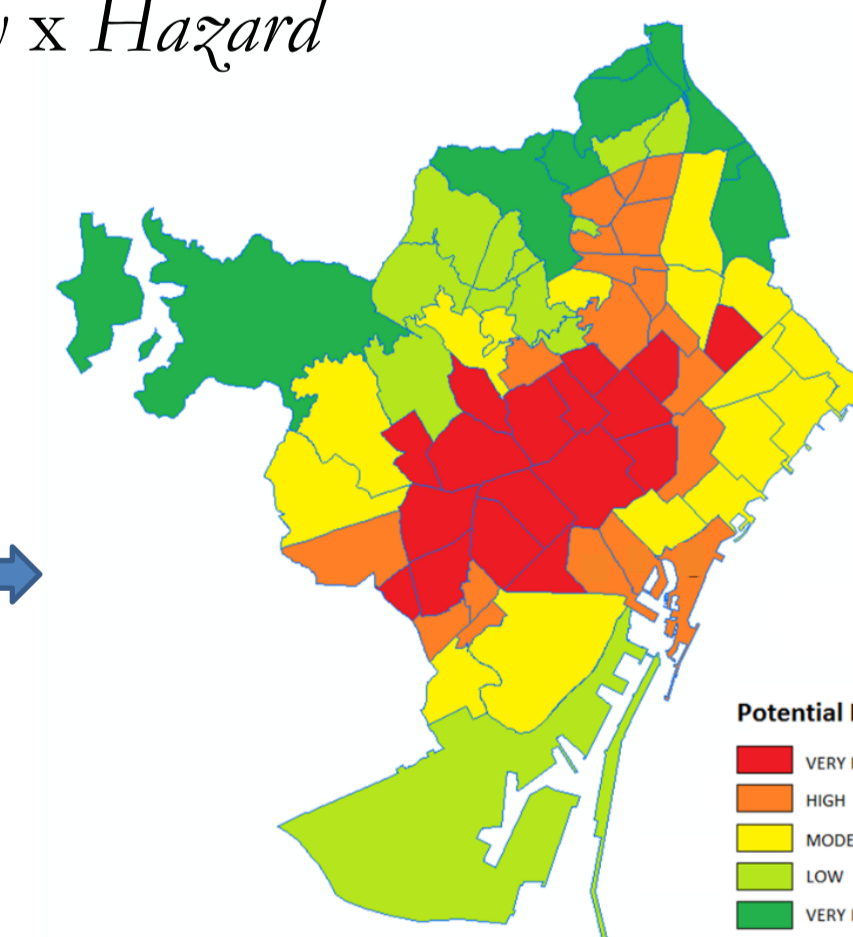Table 2. Matrix of potential risk maps coupling hazard characterization and vulnerability scenarios.

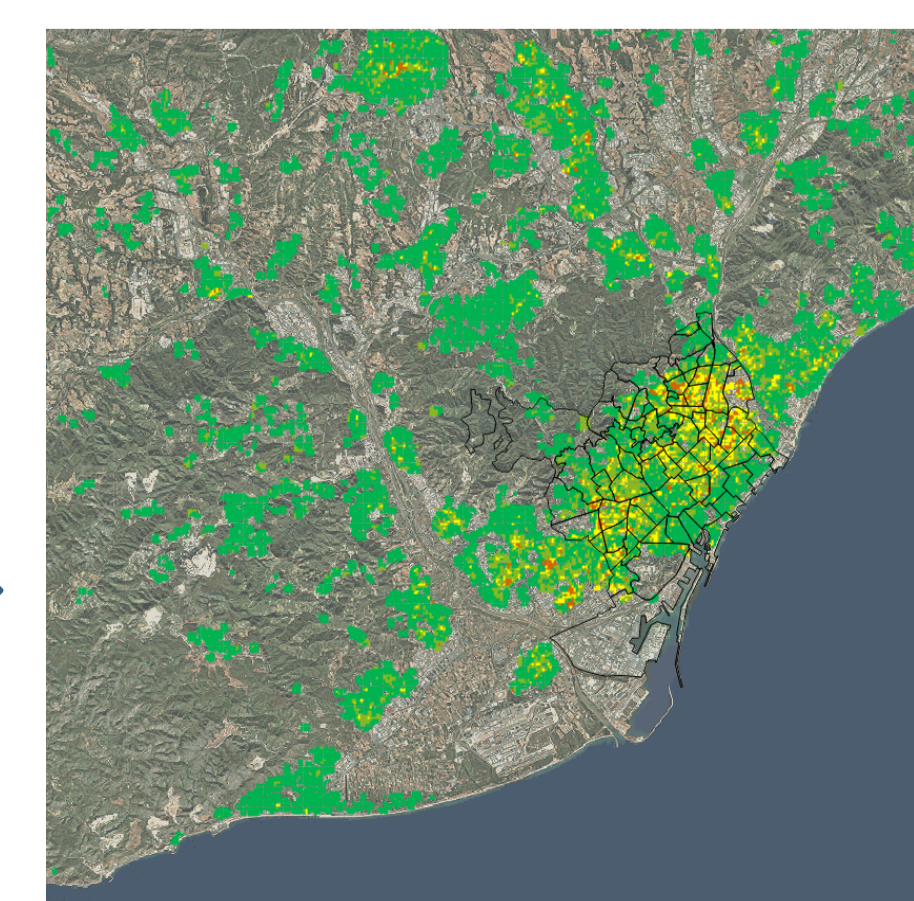Fig 12. Map of potential risk for the UHI scheme captured by TASI

Potential Risk
VERY HIGH
HIGH
MODERATE
LOW
VERY LOW

Fig 13. Map of potential risk for the percentile 95 of JJA UHI (2010-2016)

Acknowledgements

Generalitat de Catalunya
Departament de Territori i Sostenibilitat

Corresponding author: jgilabert@meteo.ub.edu
DIUB.joan.gilabert@icgc.cat