

Regulating the thermal environment in cities through Nature Based Solutions in view of counteracting energy poverty

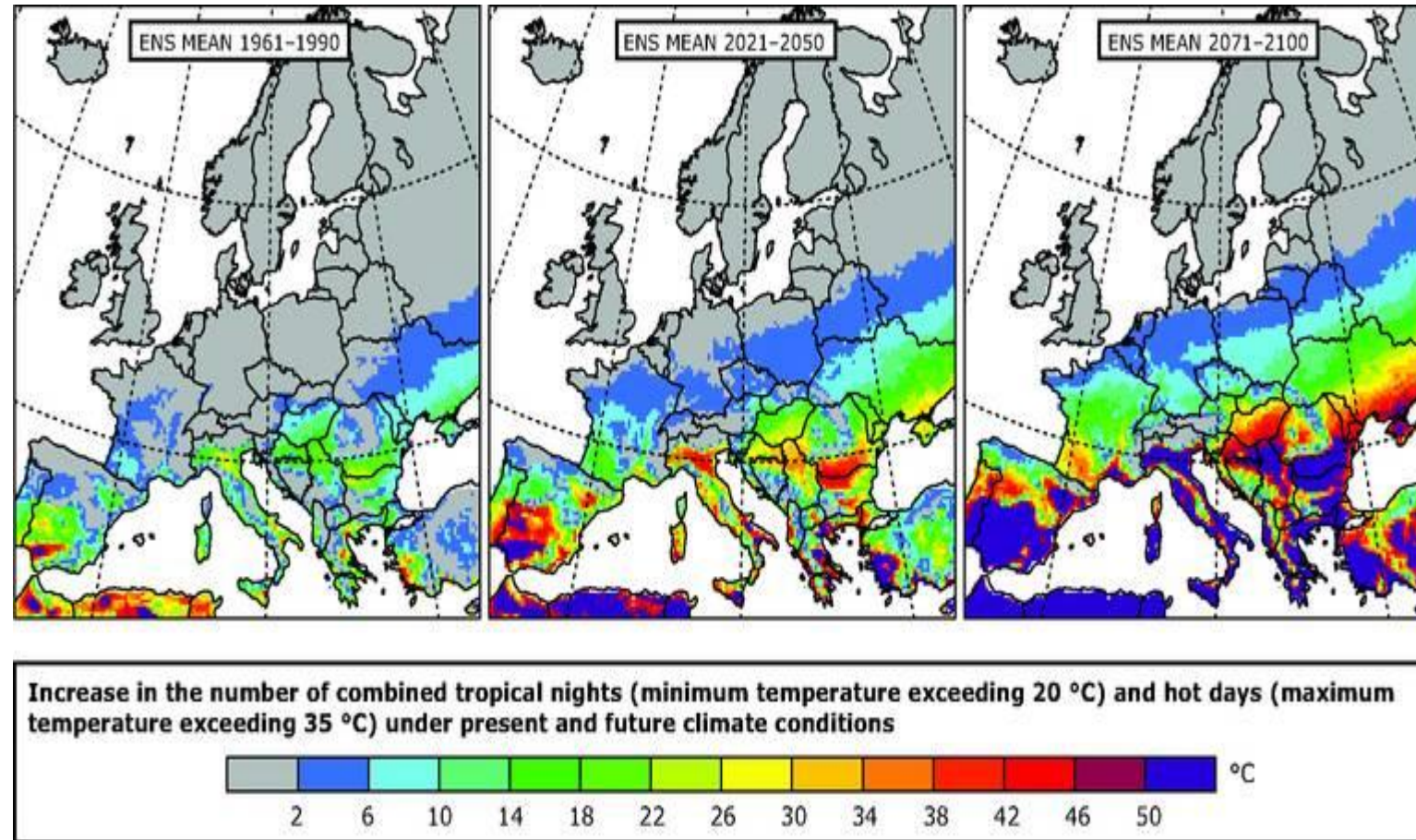
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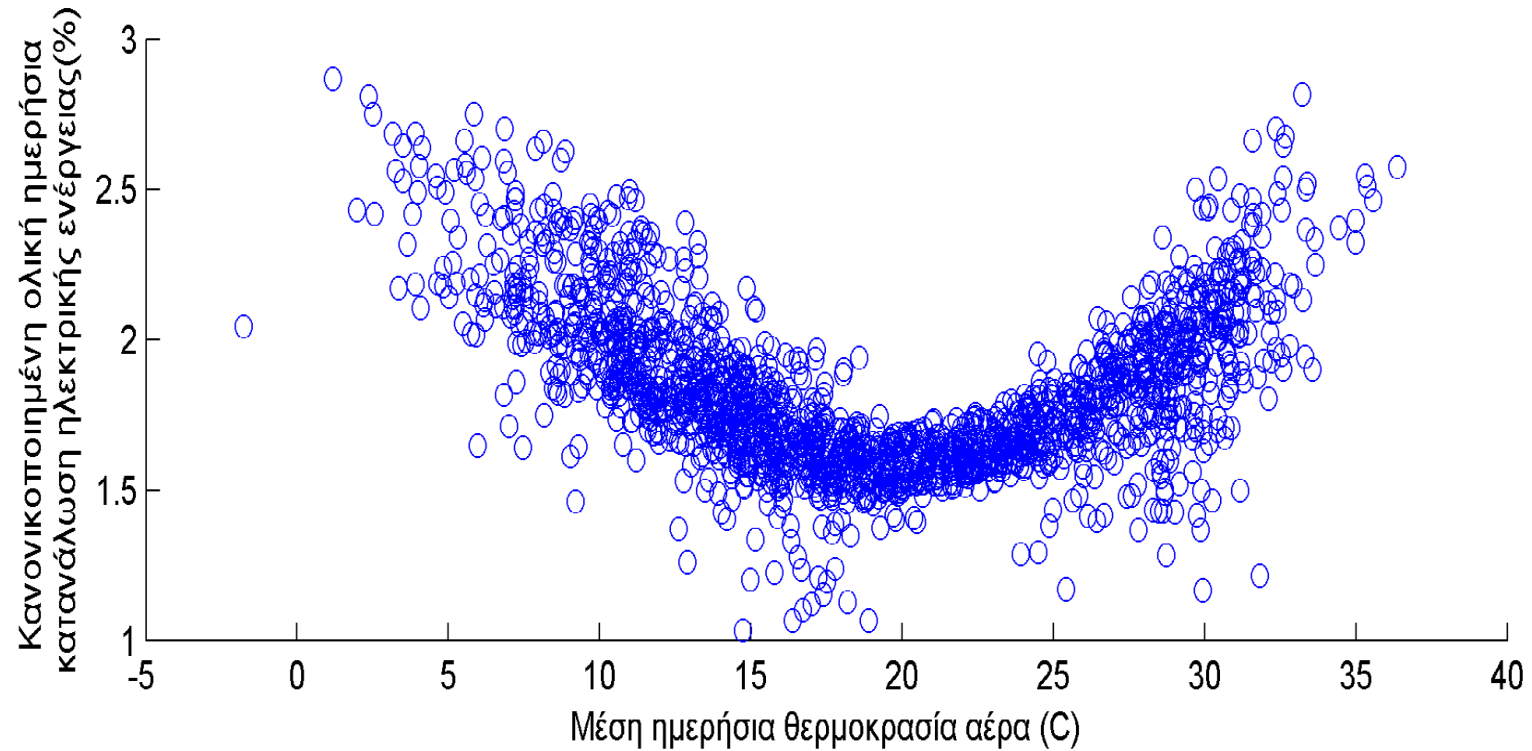


Cities become warmer



Why it is important to know the state of the thermal environment (in particular the spatial/temporal temperature distribution)?

The impact of air temperature (x axis) to the % increase of the normalized total daily electricity consumption (y axis) is more significant at temperatures > 32 deg Celsius (application for Athens)



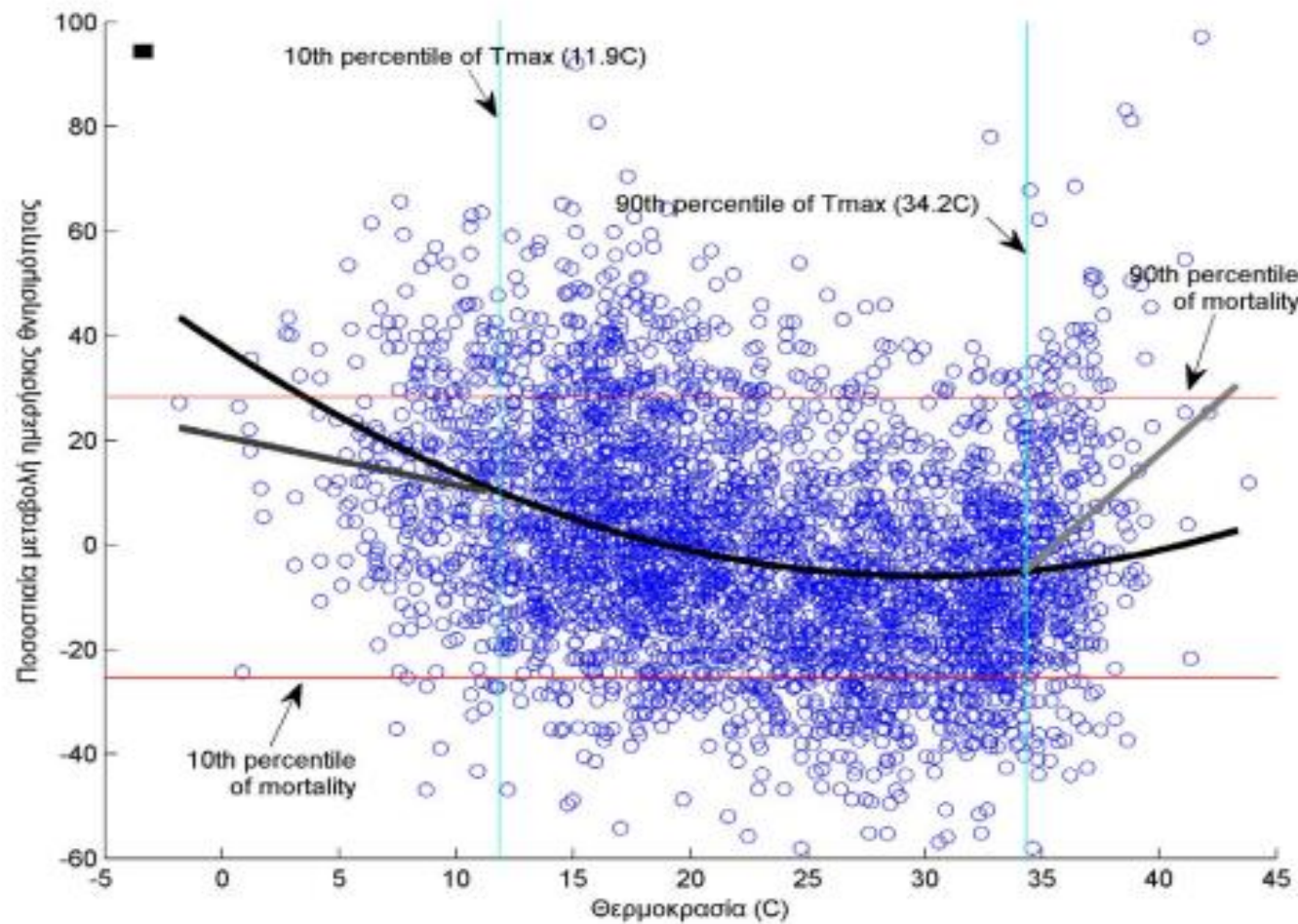
Why it is important to know the spatial and temporal temperature distribution?

The impact of the state of the thermal environment to the electricity consumption
(W/m²) for summer months (for Athens)



(Source: M. Santamouris, Univ. of Athens)

The impact of air temperature (x axis) to the % increase of the daily mortality rate (y axis) (application for Athens, for the age range > 65 years)



Source: Paravantis, J., Santamouris Mat, Cartalis C., Efthymiou Ch. and Kontoulis, N., 2017, Mortality impact associated to high ambient temperatures, heatwaves and the urban heat island in Athens, Greece, Sustainability – special issue on Urban Heat Island.3

RENATURING CITIES: not an easy task

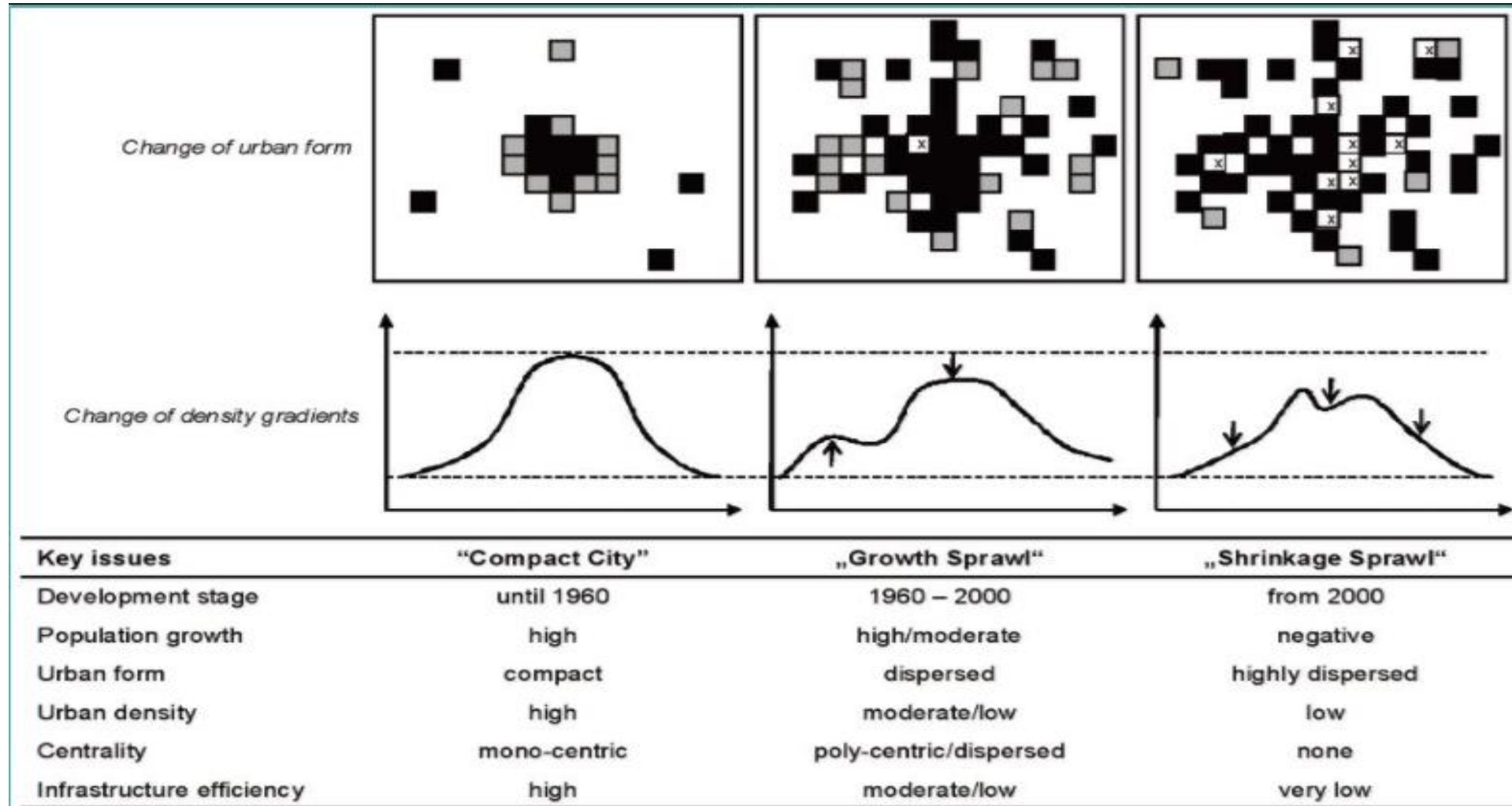


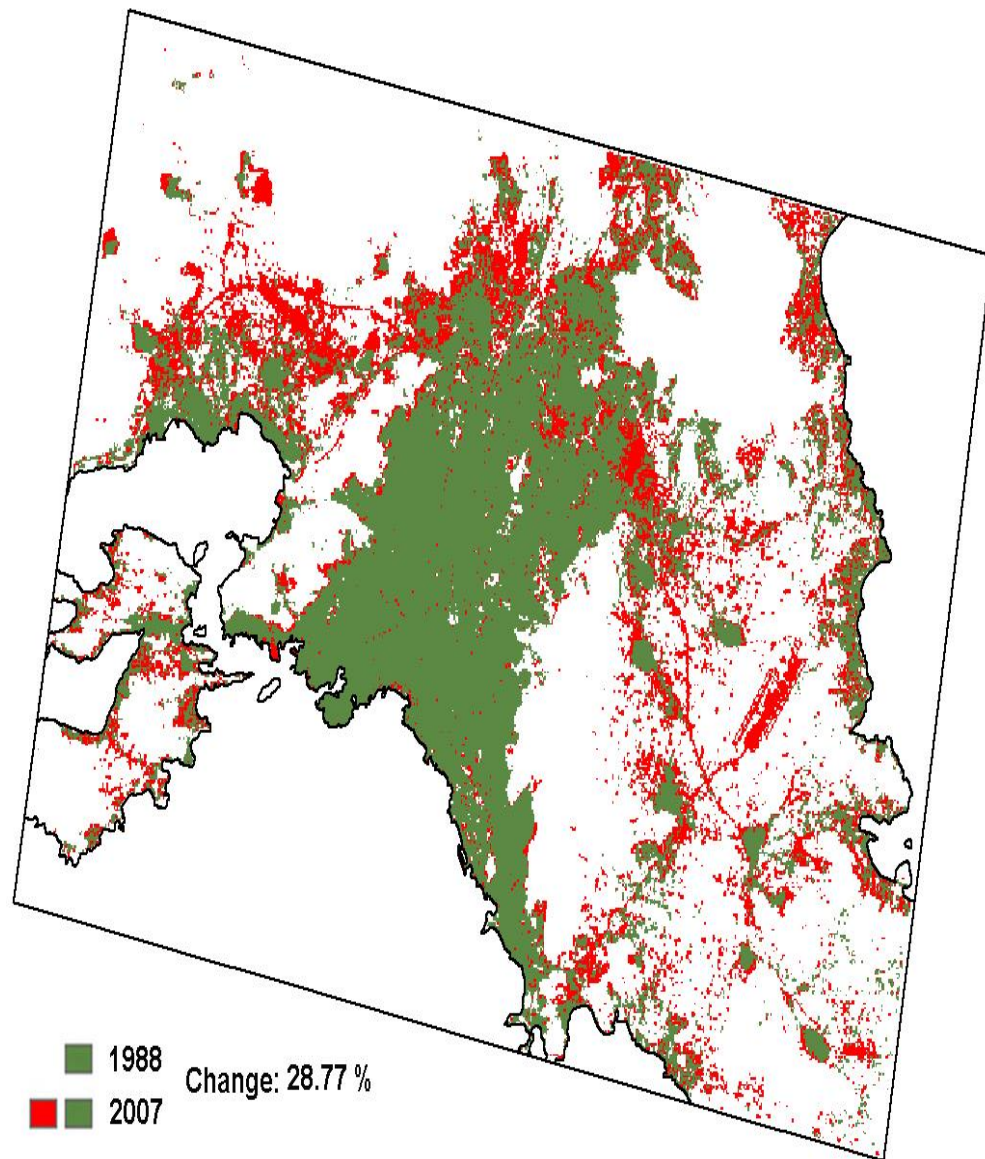
Choose the best NBS

There is no one NBS which fits all.

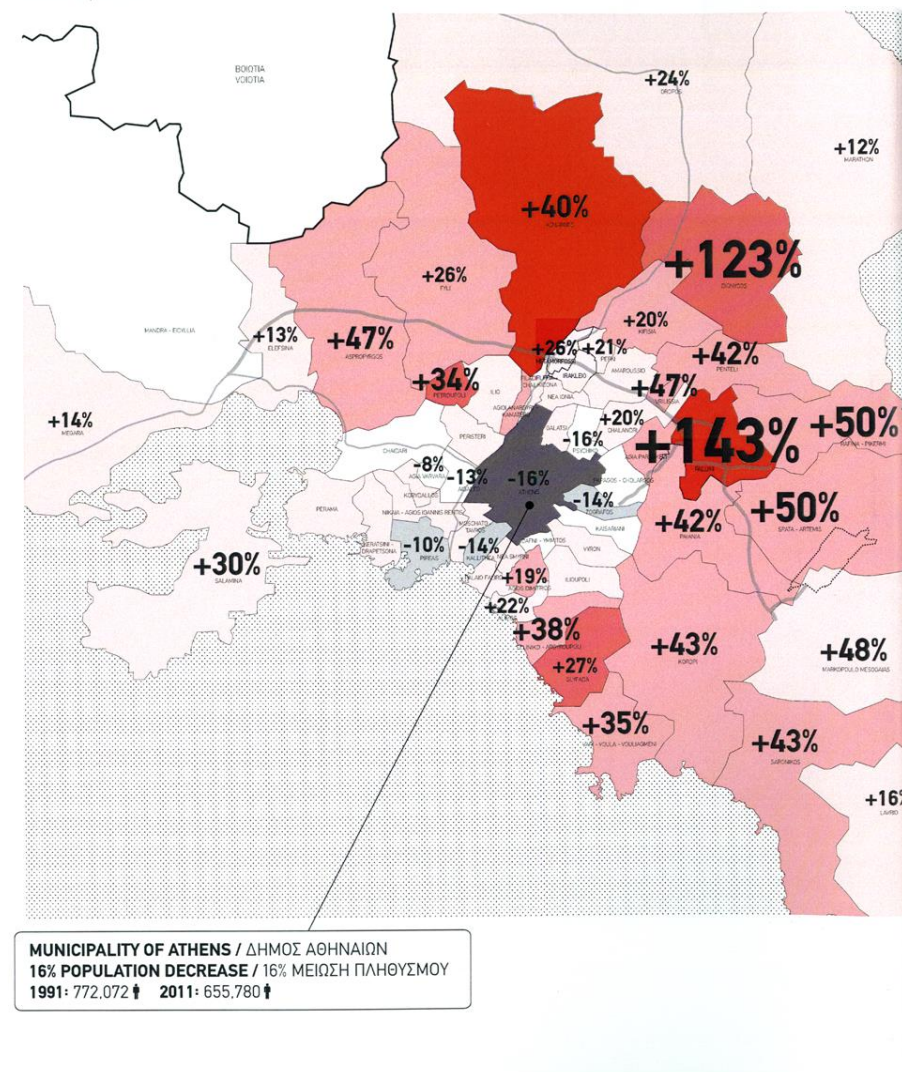
On the contrary the selection of the most appropriate NBS depends on a number of critical parameters termed as NBS SELECTION INDICATORS (NSI).

NSI 1: What is the urban growth model?

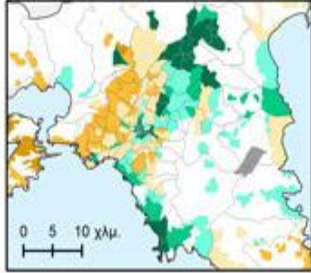




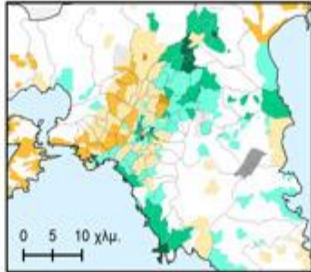
POPULATION CHANGE, ATTICA REGION 1991 - 2011
ΠΛΗΘΥΣΜΙΑΚΗ ΕΞΕΛΙΞΗ, ΠΕΡΙΦΕΡΕΙΑ ΑΤΤΙΚΗΣ 1991 - 2011
Source / Πηγή: EL.STAT.



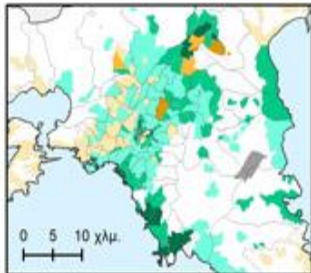
2003



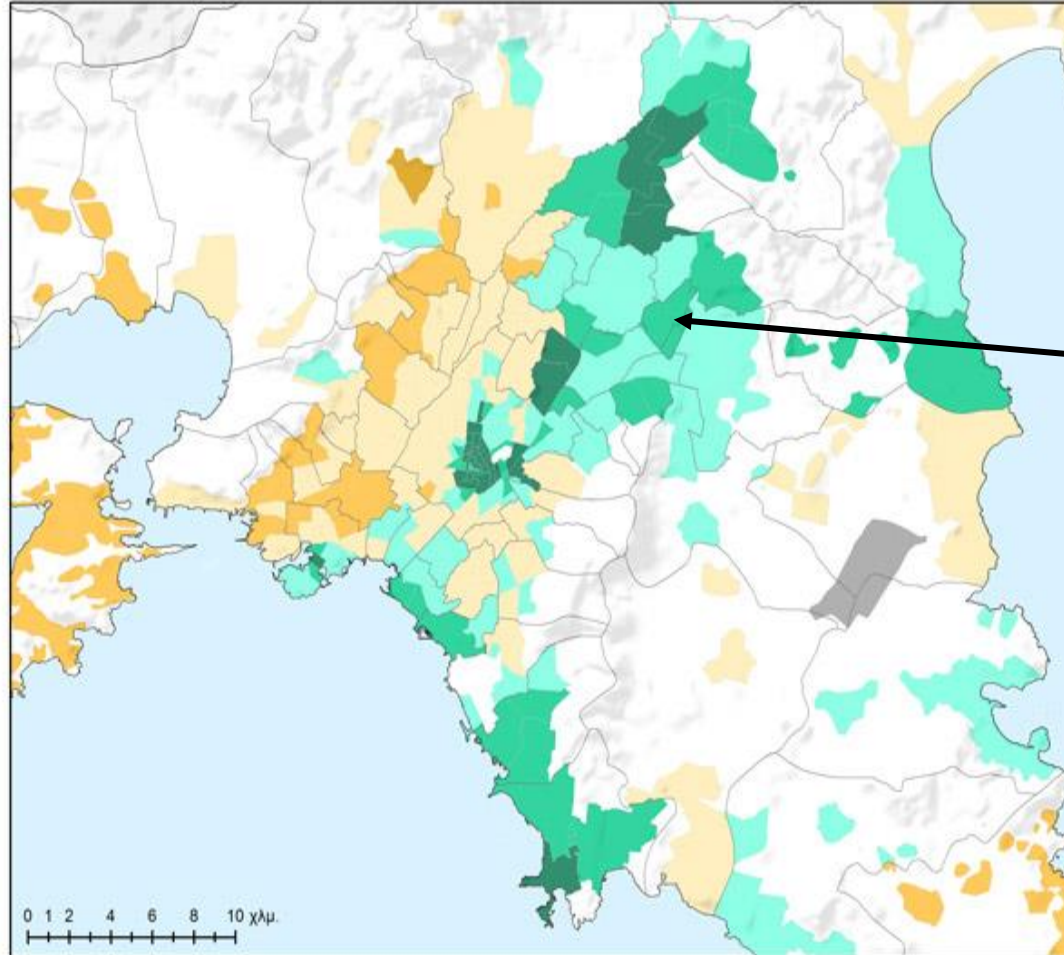
2008



2010



2013



Διοικητικά όρια

Όρια δήμων

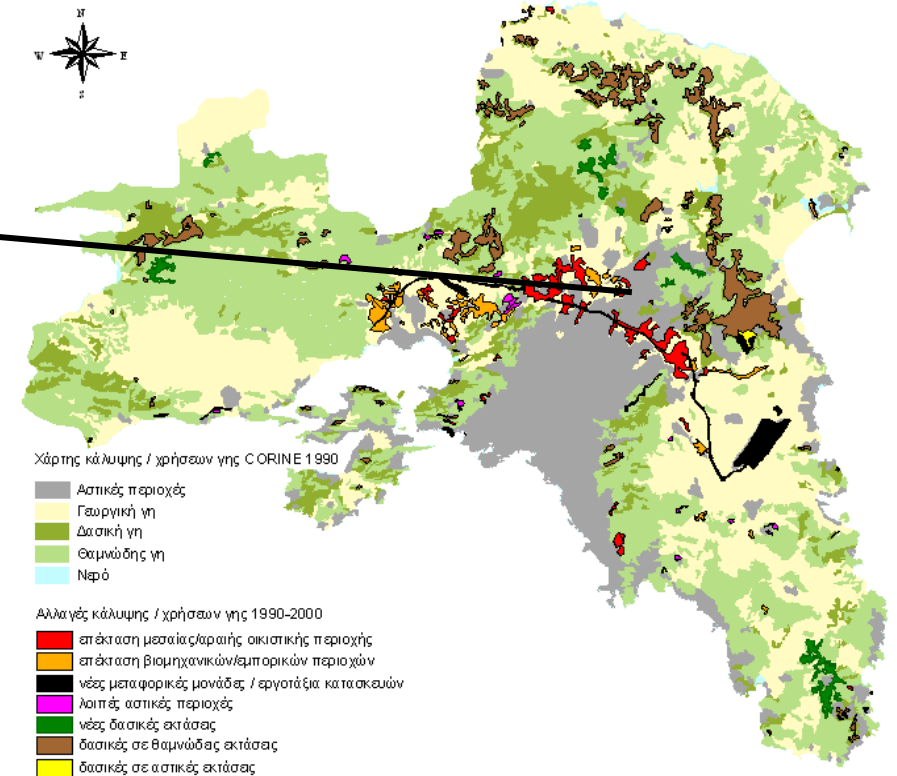
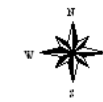
Όρια ΤΚ

Δείκτης ανισότητας (Gini)

Εισοδηματικά κλιμάκια



Inequality indicator
Gini

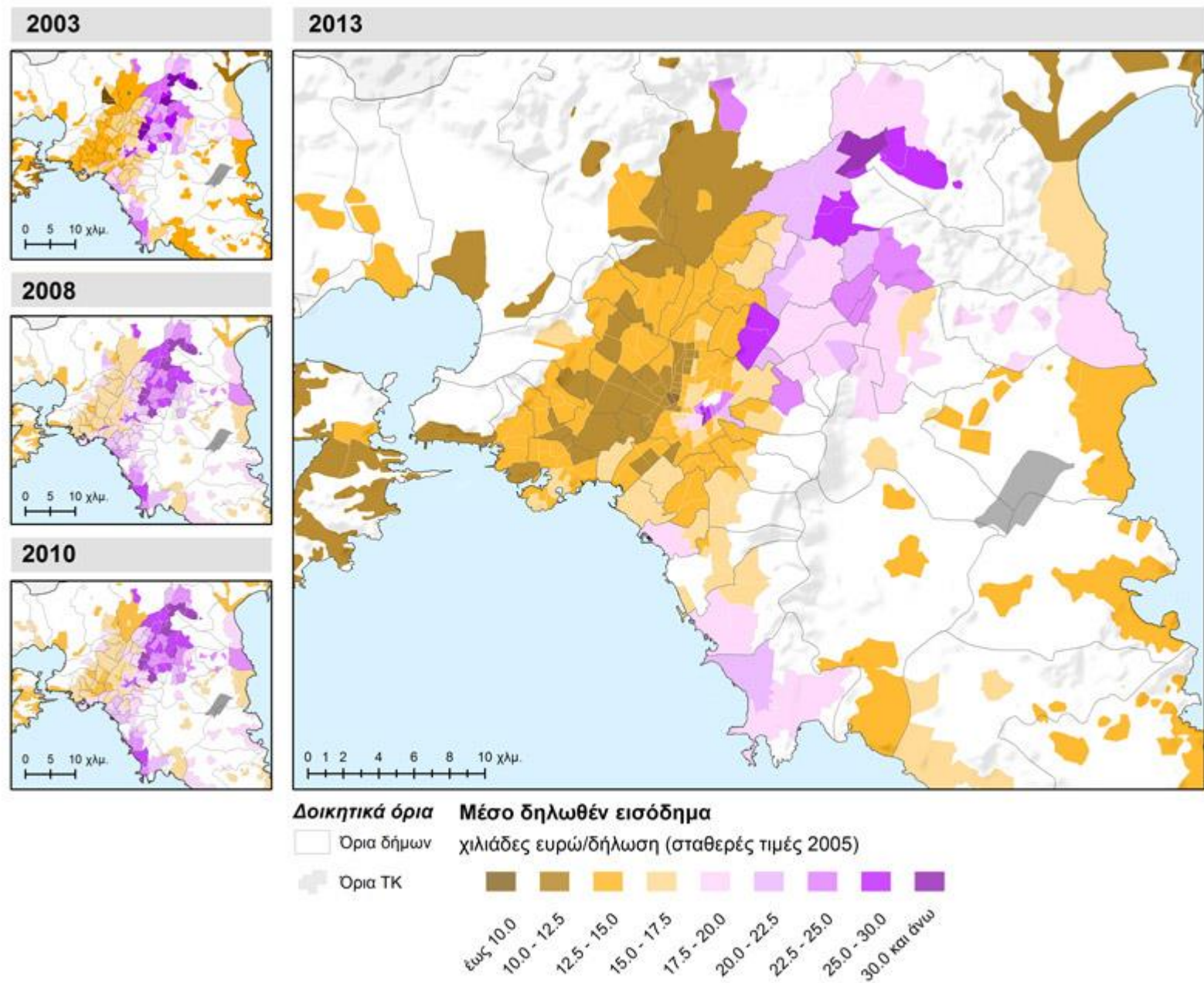


Χάρτης κάλυψης / χρήσεων γης CORINE 1990

- Αστικές περιοχές
- Γεωργική γη
- Δασική γη
- Θαμνώδης γη
- Νερό

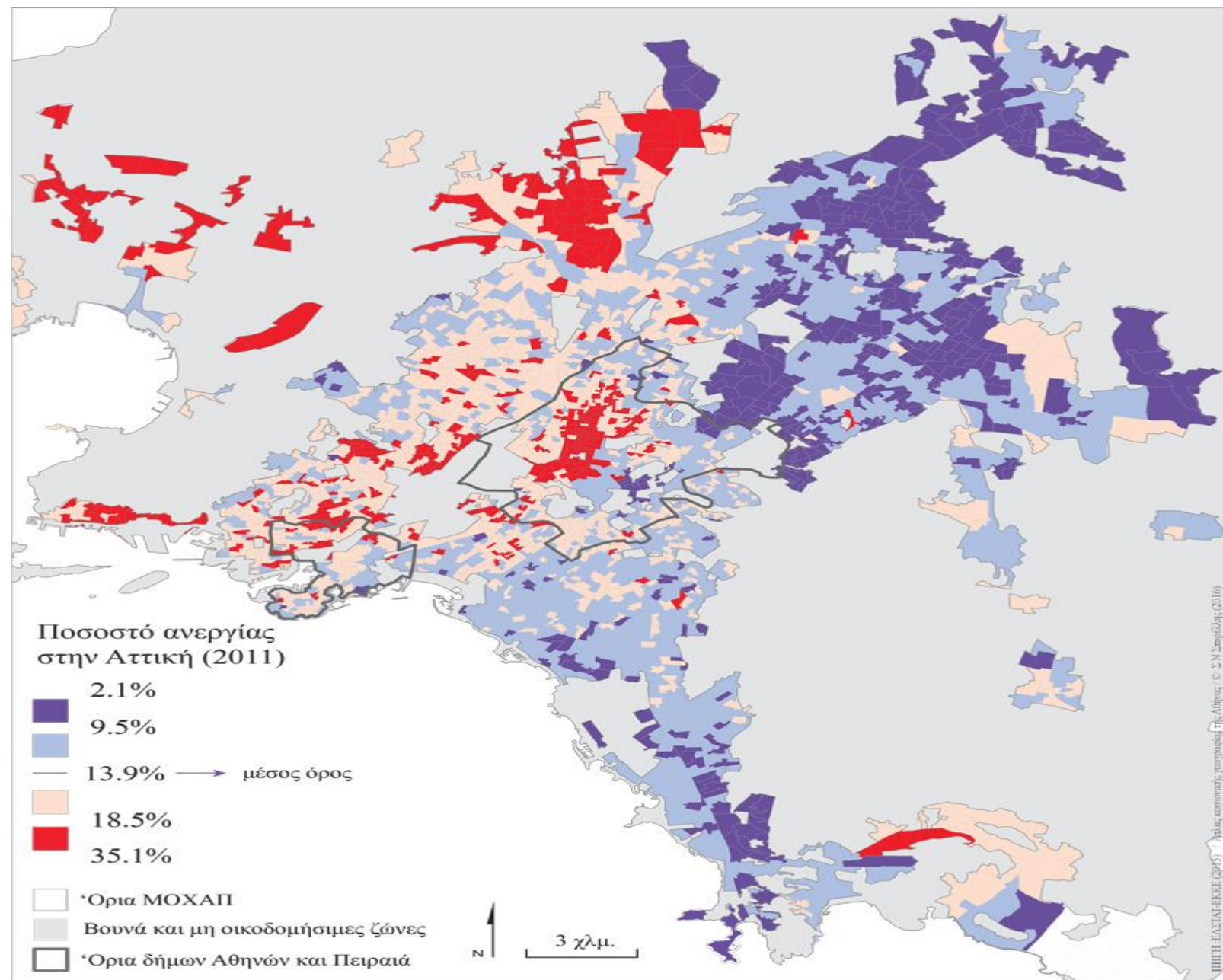
Αλλαγές κάλυψης / χρήσεων γης 1990-2000

- επέκταση μεσαίας/αραιής οικιστικής περιοχής
- επέκταση βιομηχανικών/εμπορικών περιοχών
- νέες μεταφορικές μονάδες / εργοστάσια κατασκευών
- λοιπές αστικές περιοχές
- νέες δασικές εκτάσεις
- δασικές σε θαμνώδεις εκτάσεις
- δασικές σε αστικές εκτάσεις



**Average income
in keuros**

Unemployment Rate 2011

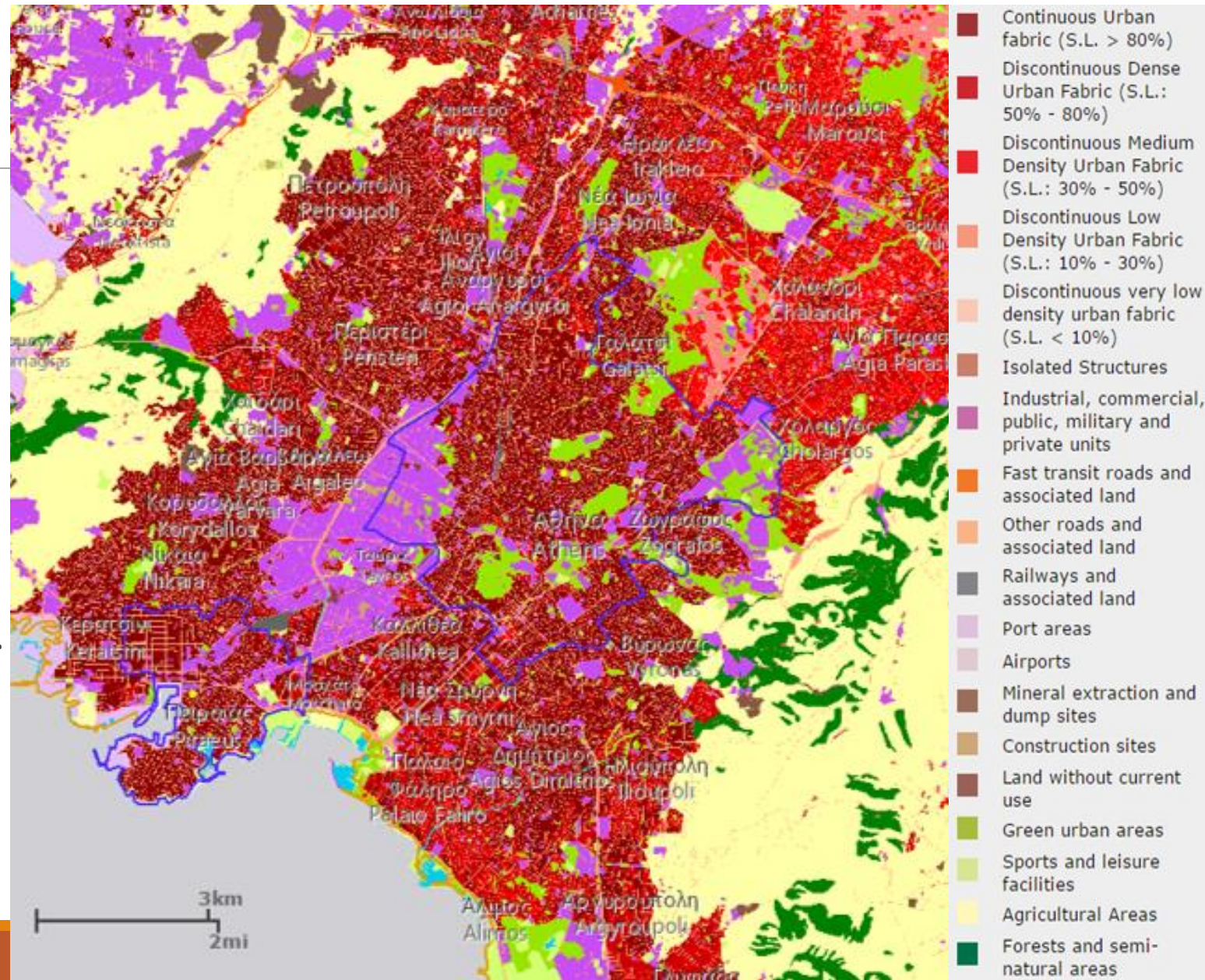


NSI 2. What is the Land Use-Land Cover (LULC) pattern for the city concerned

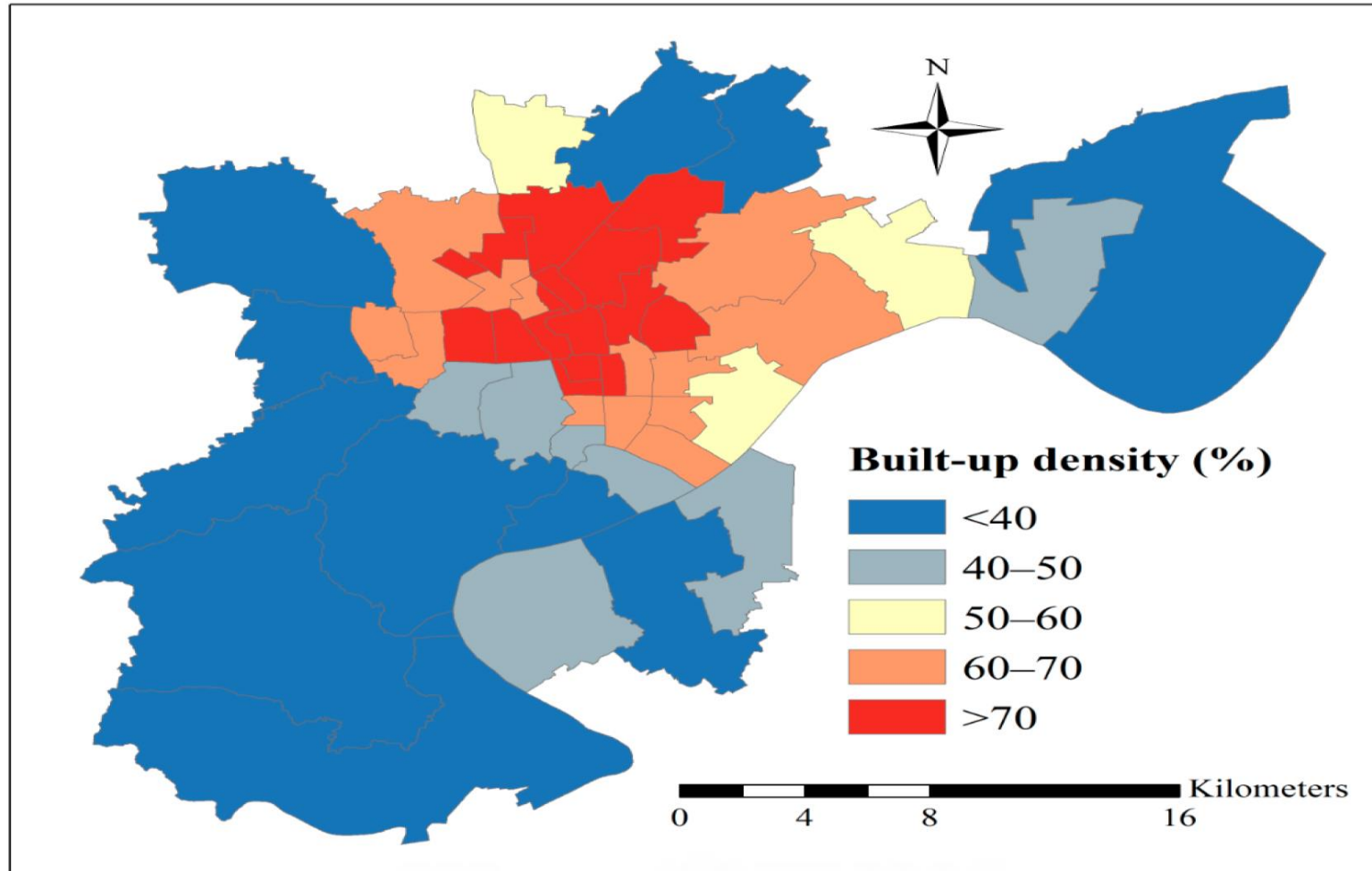
Copernicus Urban Atlas project 2012 → LULC

Basic classes:

1. **Continuous urban fabric: Housing.**
Mean impervious value > 80%.
2. **Non continuous urban fabric:** Housing over 20%, open space, private gardens, disperse vegetation. Mean impervious value: 10- 80%.
3. **Industrial-Commerical-Public Buildings:**
artificial surfaces (cement, asphalt, etc.).
4. **Urban green:** mostly parks



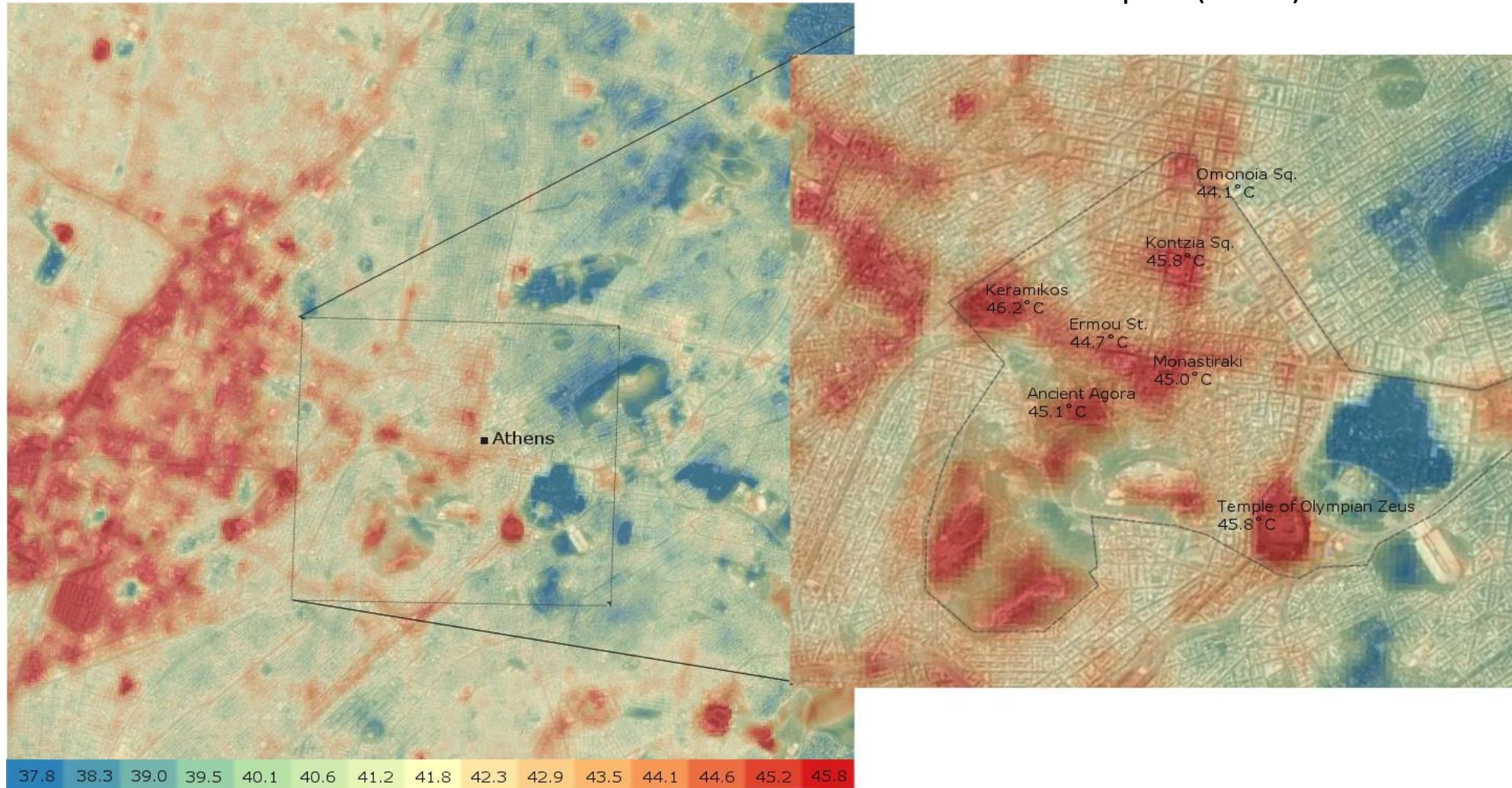
NSI 3. What is the built-up density per city area?



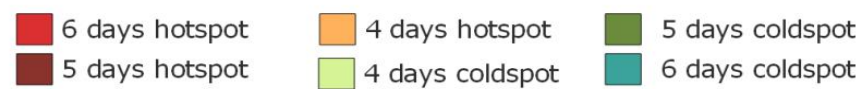
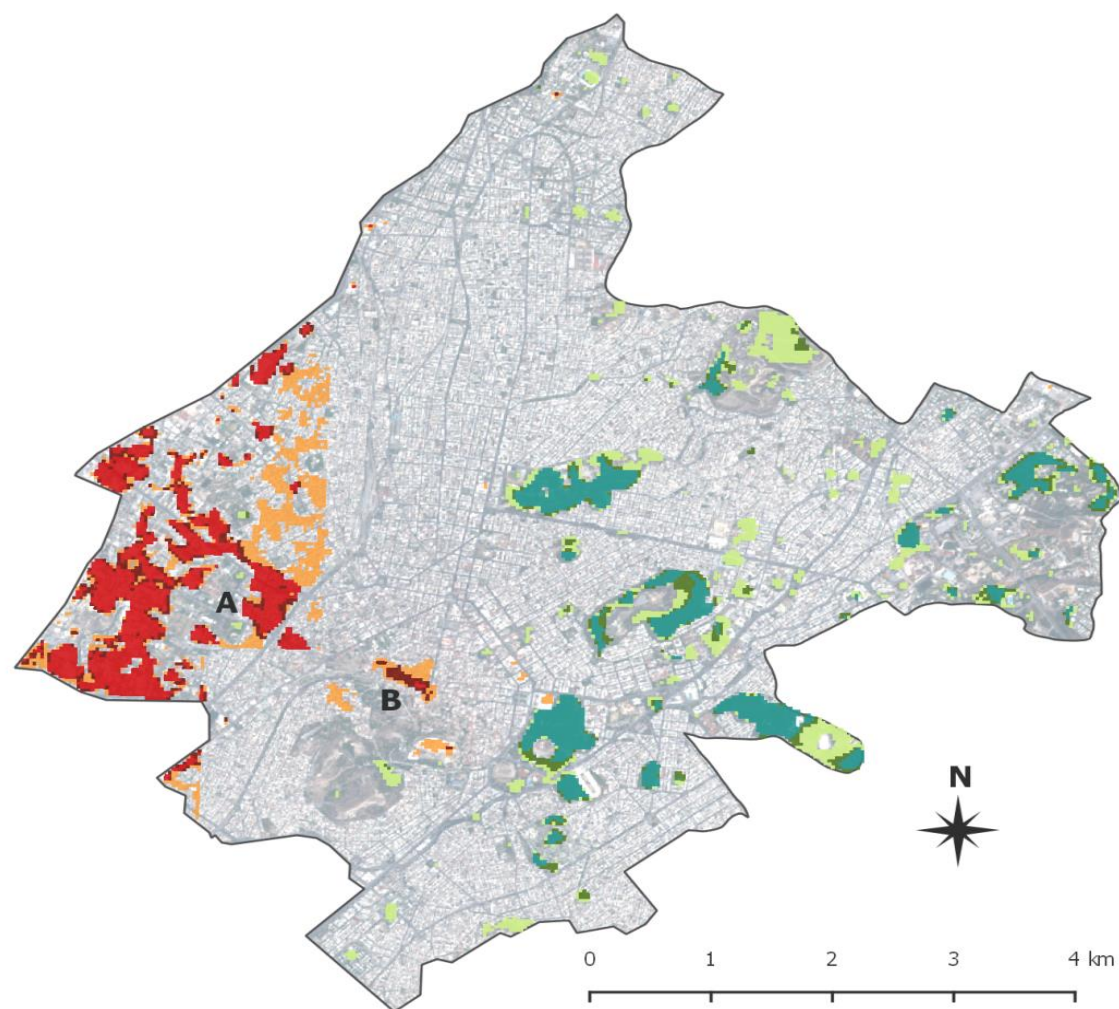
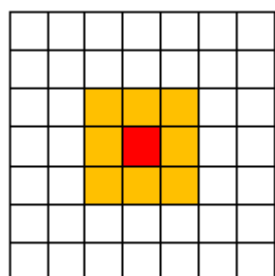
Sheng Zheng, Xueyuan Zhou, Ramesh P. Singh, Yuzhe Wu, Yanmei Ye and Cifang Wu (2017), The Spatiotemporal Distribution of Air Pollutants and Their Relationship with Land-Use Patterns in Hangzhou City, China, Atmosphere.

NSI 4. What is the state of the thermal environment? Are there any Hot spots (i.e. areas with systematically higher temperatures compared to neighboring ones)

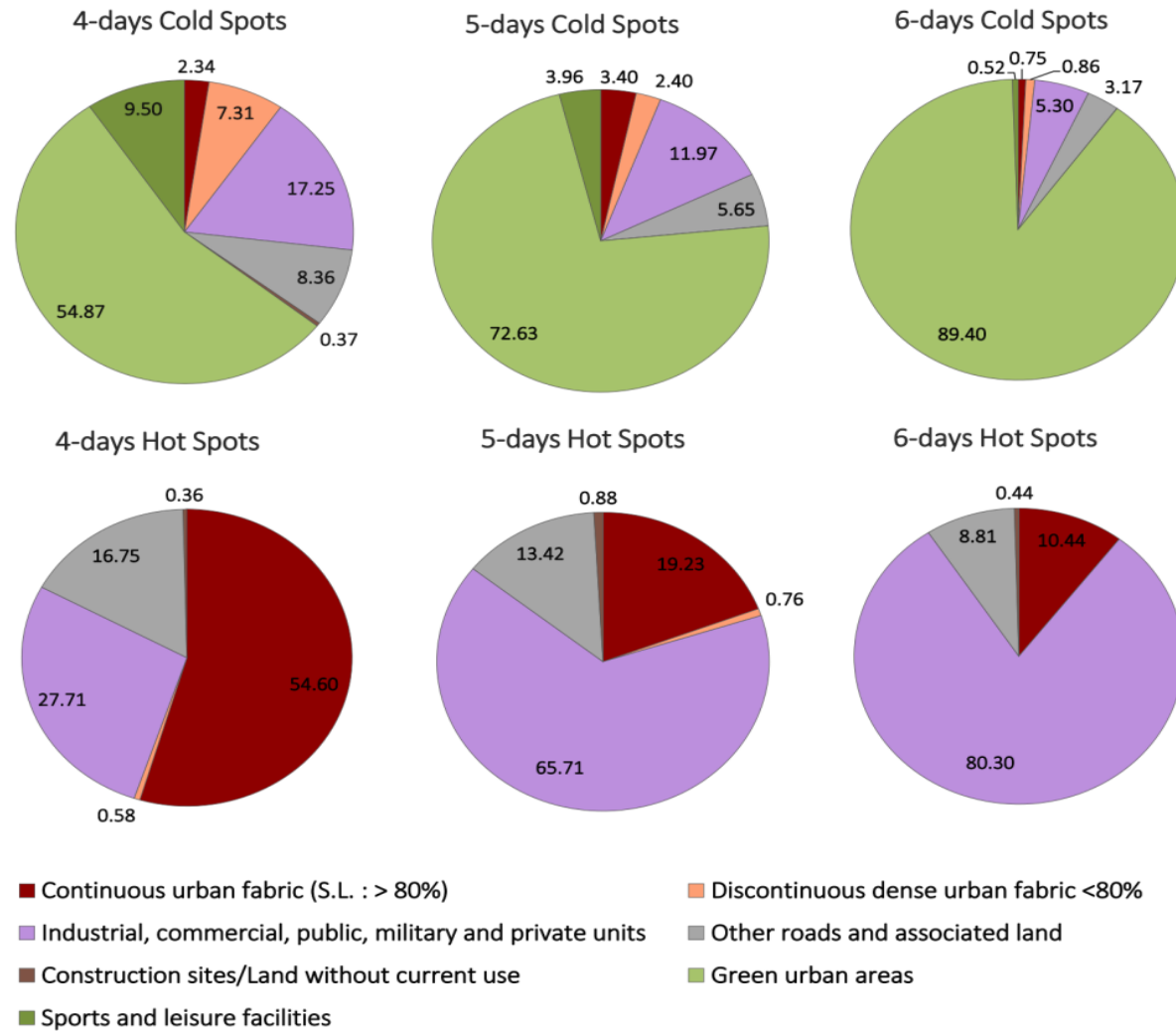
Thermal Hot Spots (in red)



Source: Cartalis, C., Santamouris M., Asimakopoulos, D., Polydoros A., Mavrakou Th, 2015. Identifying Hot Spots in Urban Areas in Support of Microclimatic Studies in the City of Athens, Including Its Historic Centre, ESA – DRAGON Symposium, Interlaken.

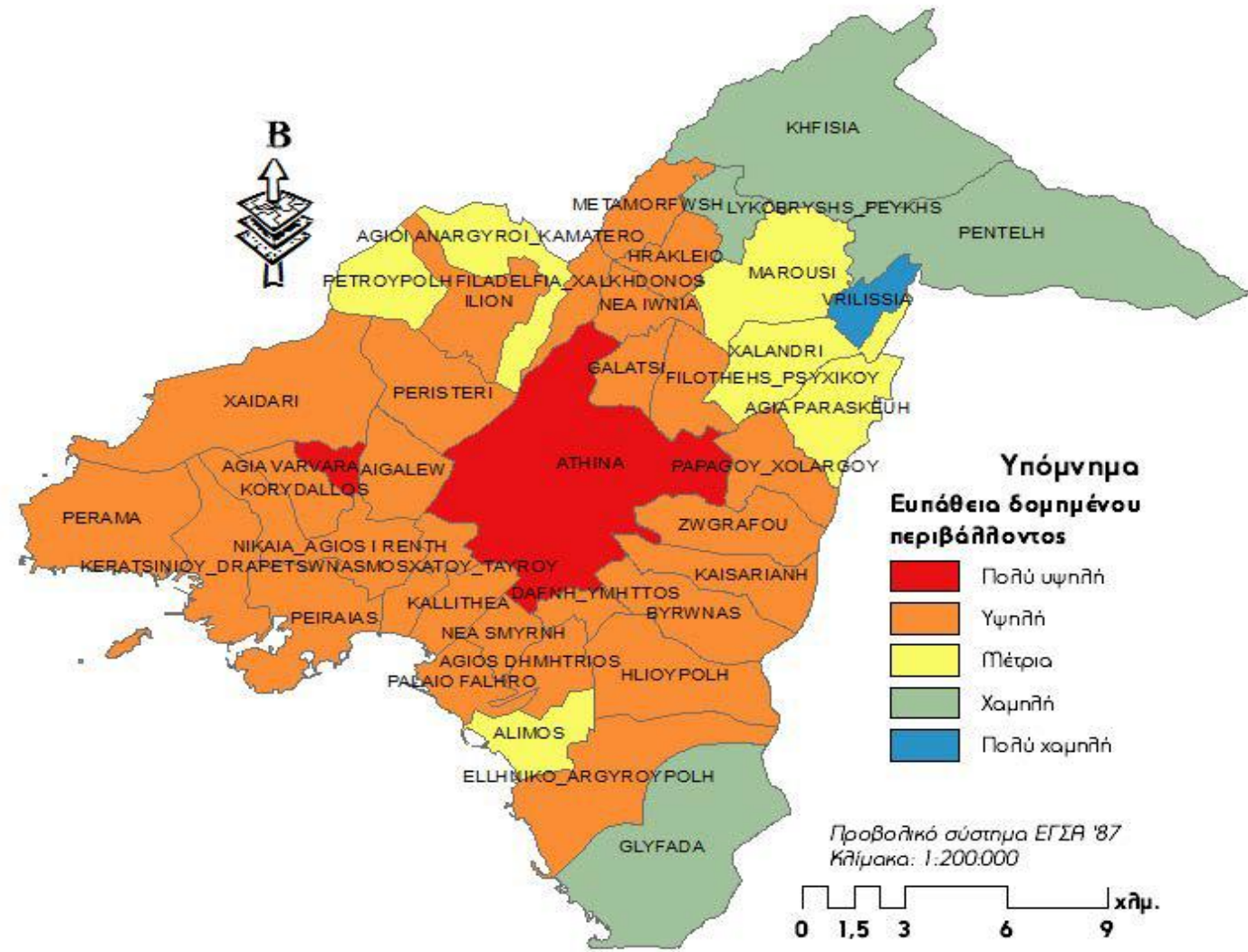


Source: Remote Sensing Unit, University of Athens (unpublished material)



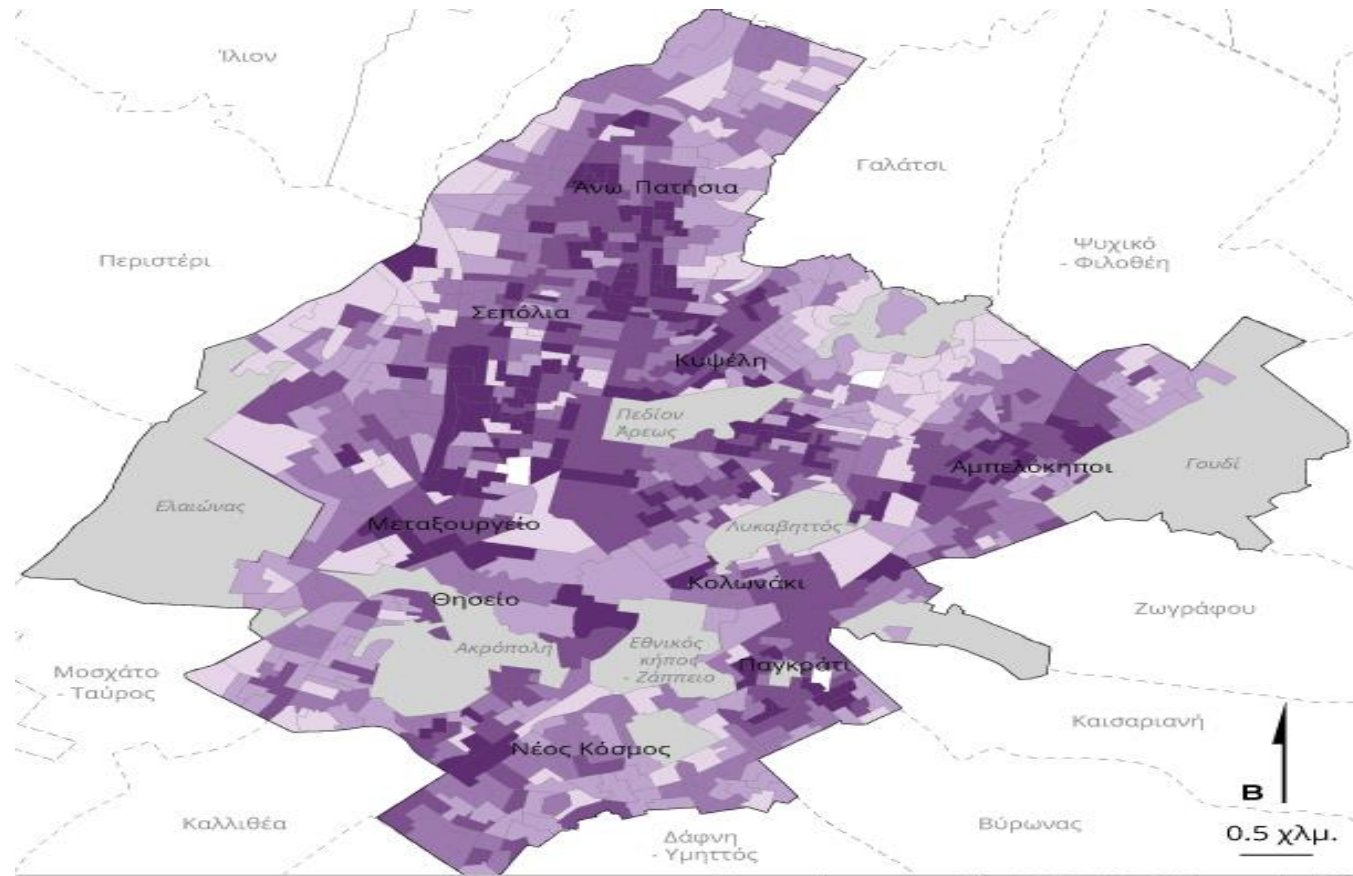
NSI 5. Age of the building environment and collateral characteristics

The age of buildings is related to their vulnerability in terms of the prevailing thermal conditions



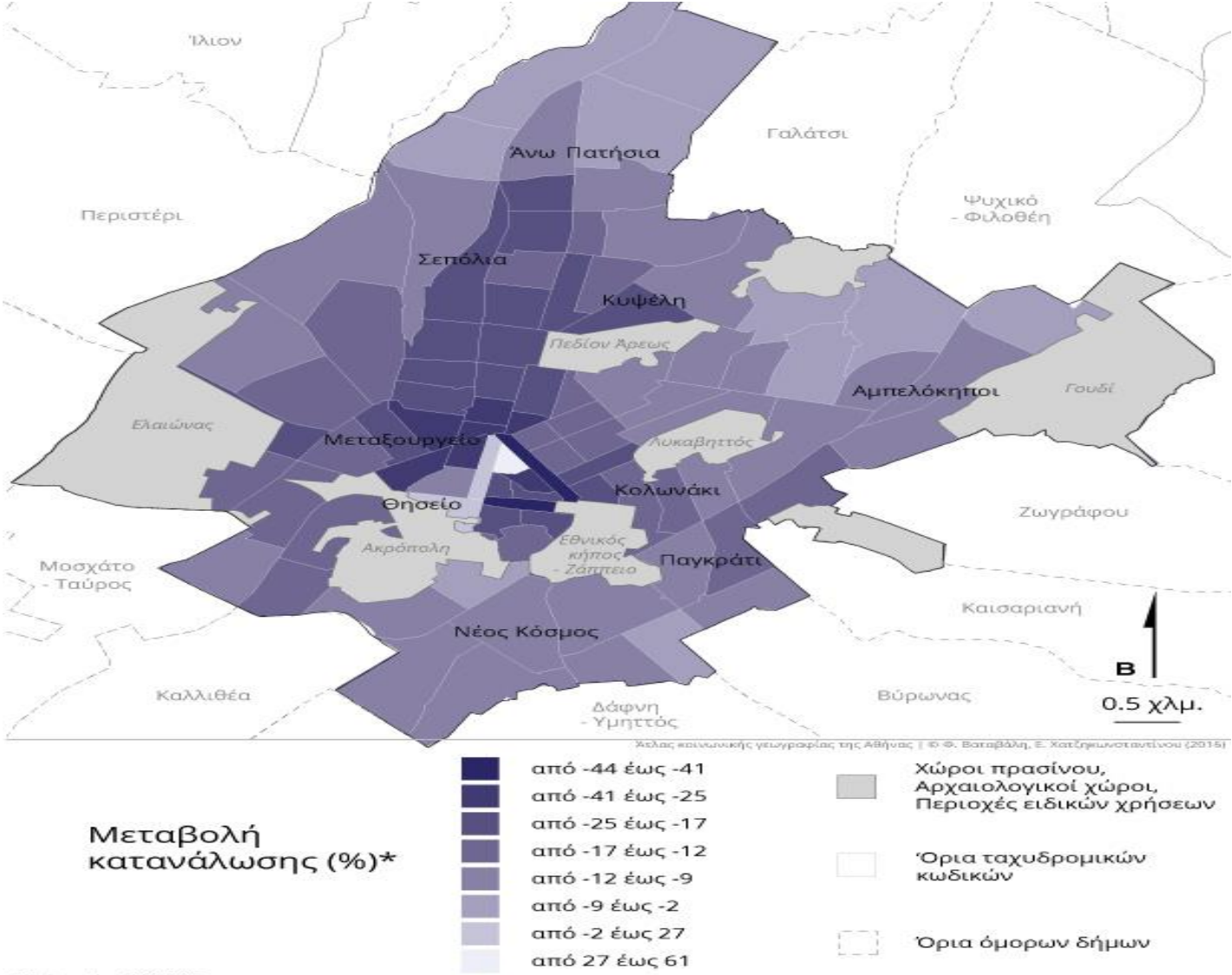
Red: High vulnerability,
70% of the buildings have been
constructed before the 1980s
Orange: High vulnerability 50-70%
of the buildings have been
constructed before the 1980s
Yellow: Medium; Green: Low and
Blue: Very low

Buildings without insulation



*Πηγή στοιχείων: ΕΛΣΤΑΤ - Απογραφή 2011

Change in electricity
consumption
(%)



NSI 6. Critical infrastructures

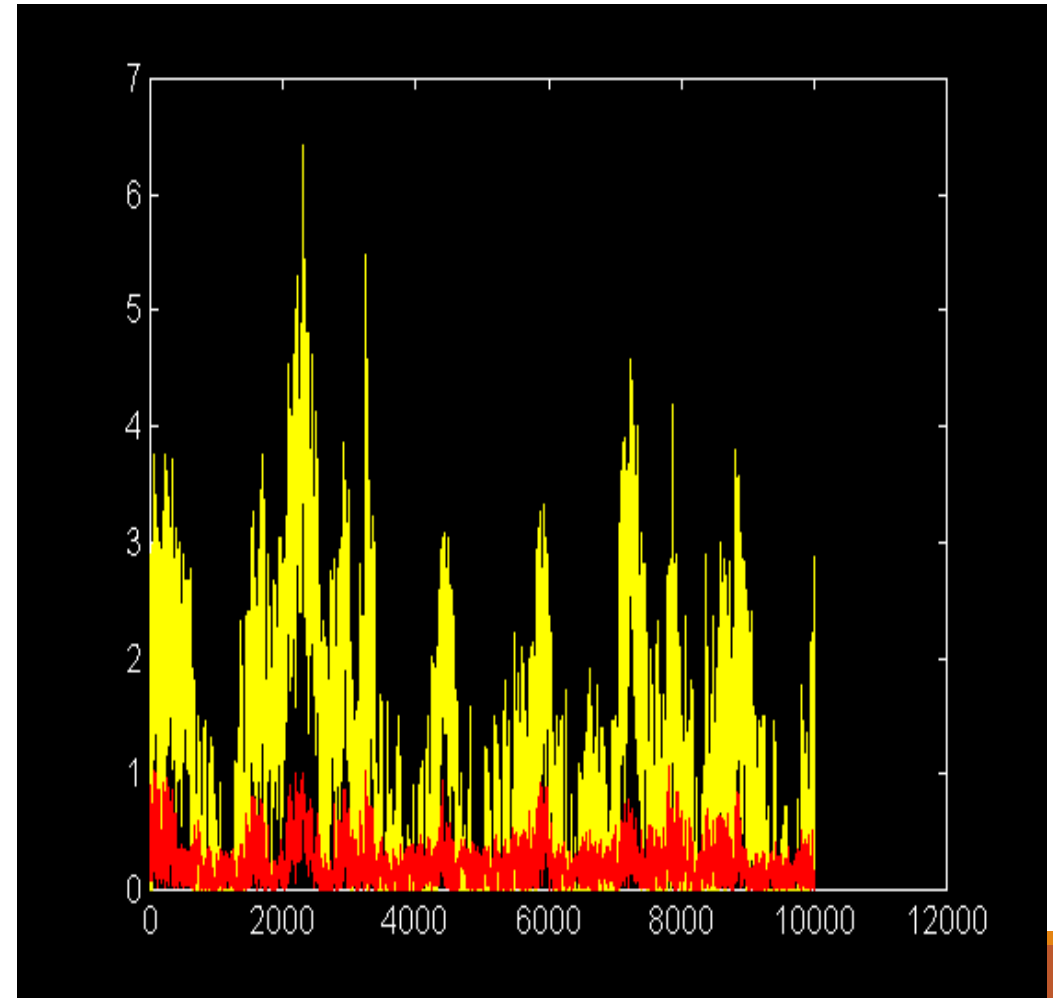
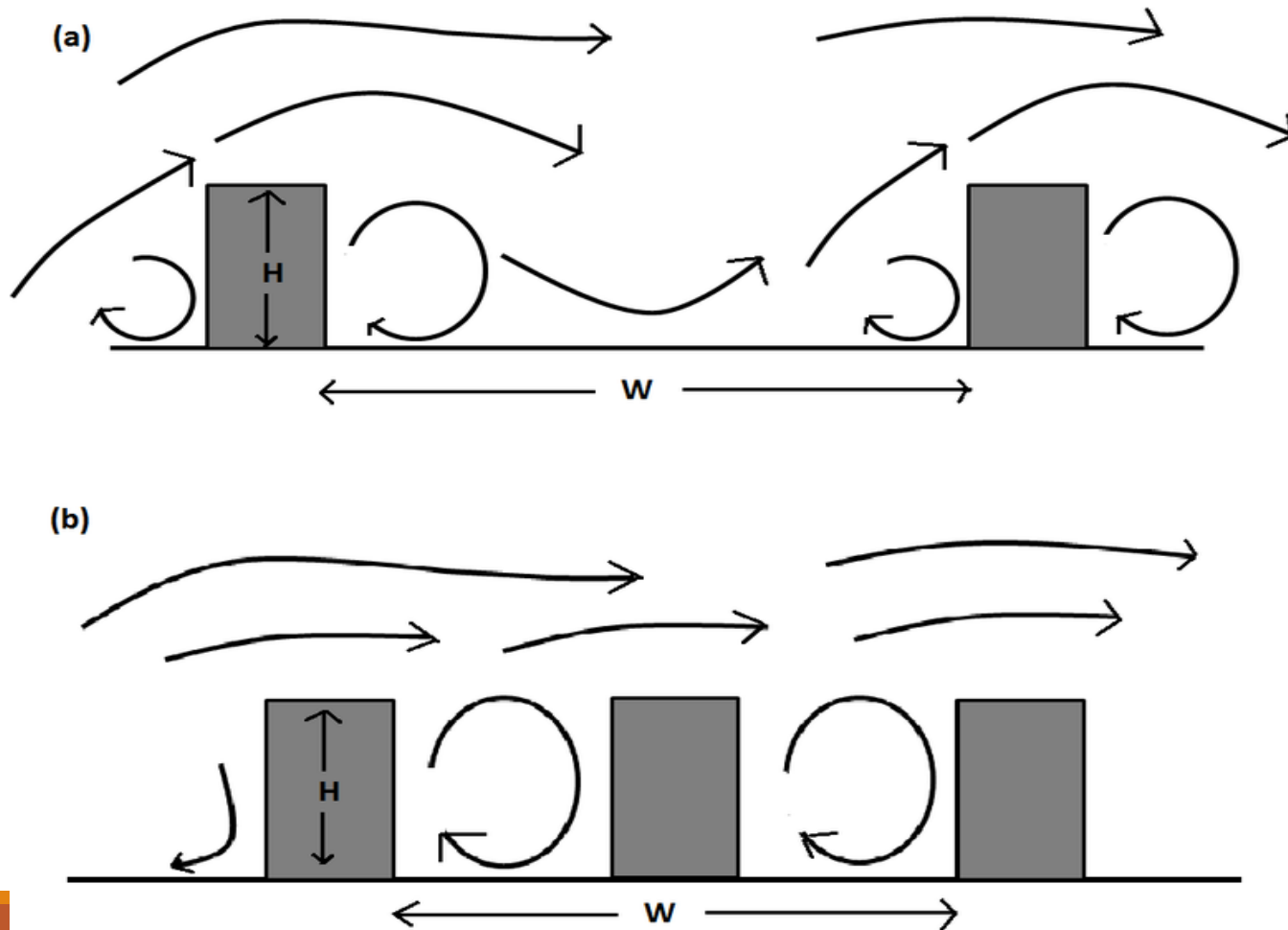
The map denotes (with black bullets) the schools which are located in hot spot areas, i.e, in areas where temperatures are systematically higher.

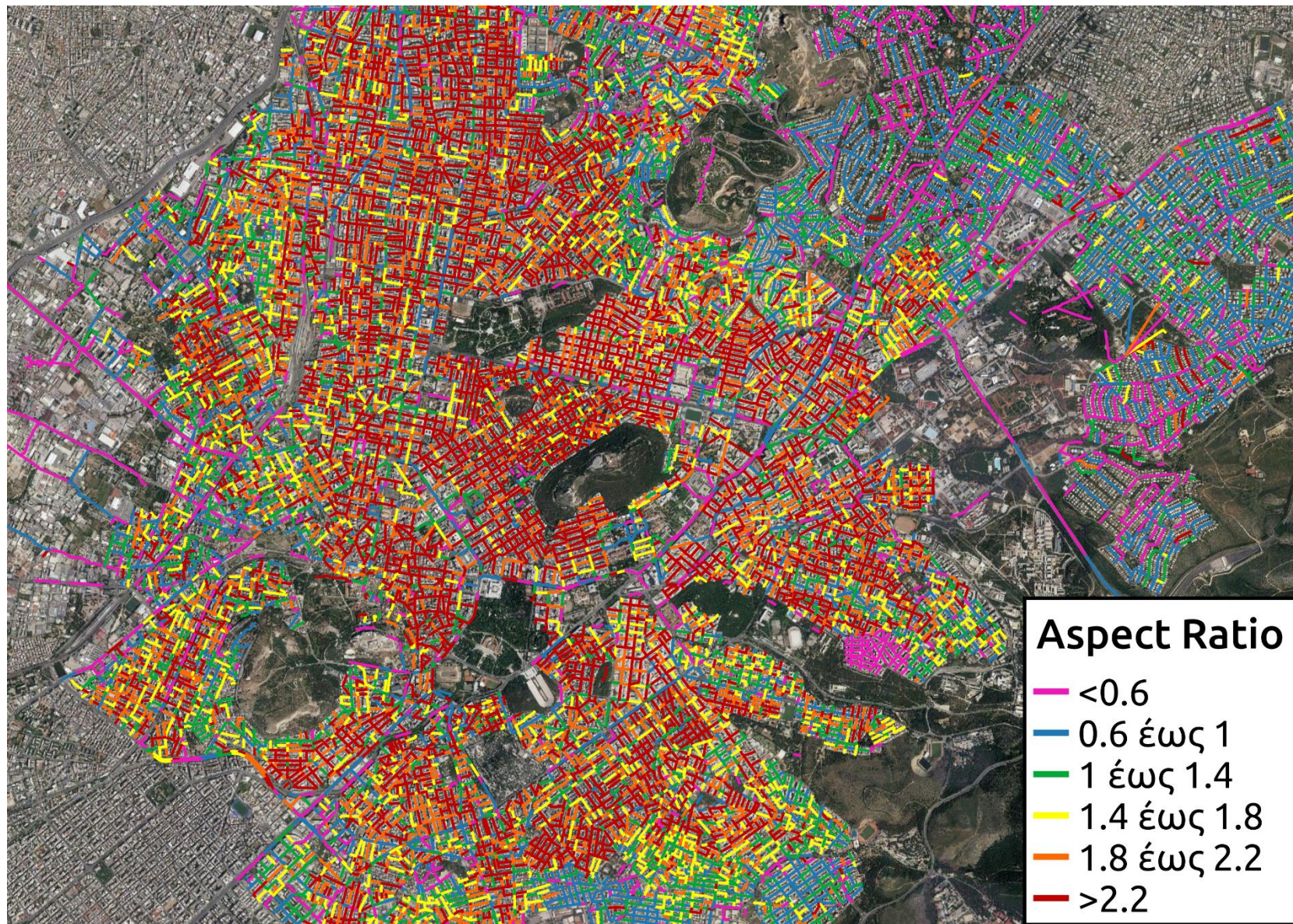


NSI 7. Urban planning geometric characteristics

If $H/W > 1$, then air pollution is dispersed and heat is transferred. The opposite holds for $H/W < 1$.

Wind speed (m/sec) at the top of buildings
In yellow and at the street level in red.





Source: Remote Sensing Unit, University of Athens (unpublished results)

NSI 8. (in)Homogeneity of the thermal environment

A homogeneous thermal environment (that is when ΔT between neighboring areas tends to 0), restricts horizontal air mass motion.

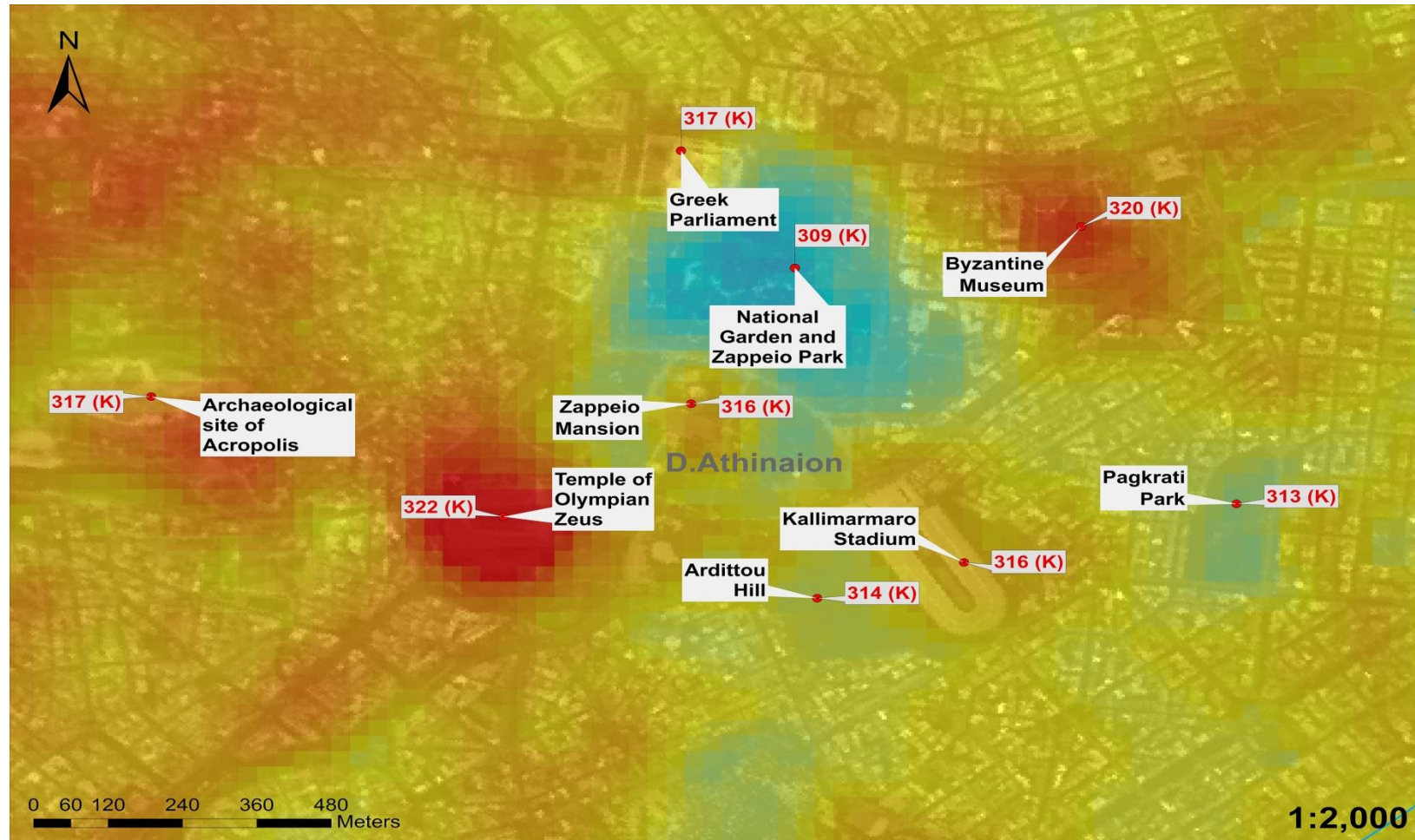


Image source: National Observatory of Athens

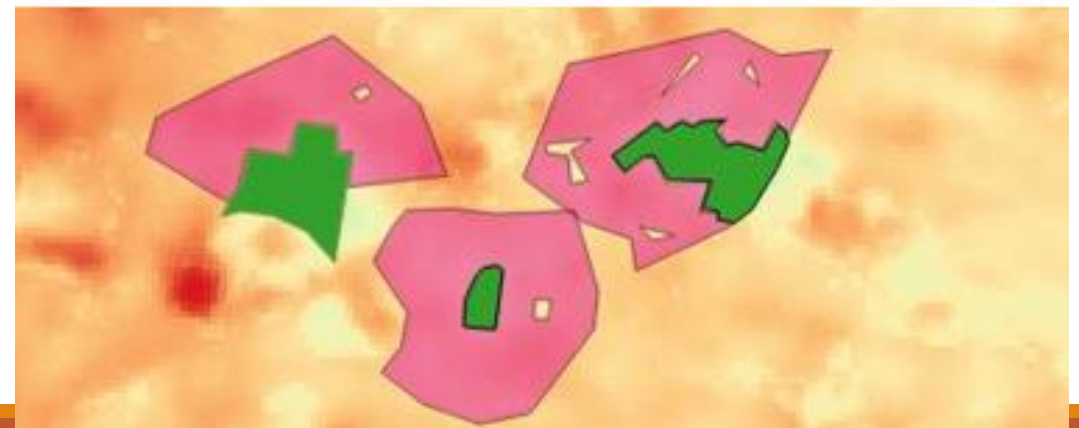
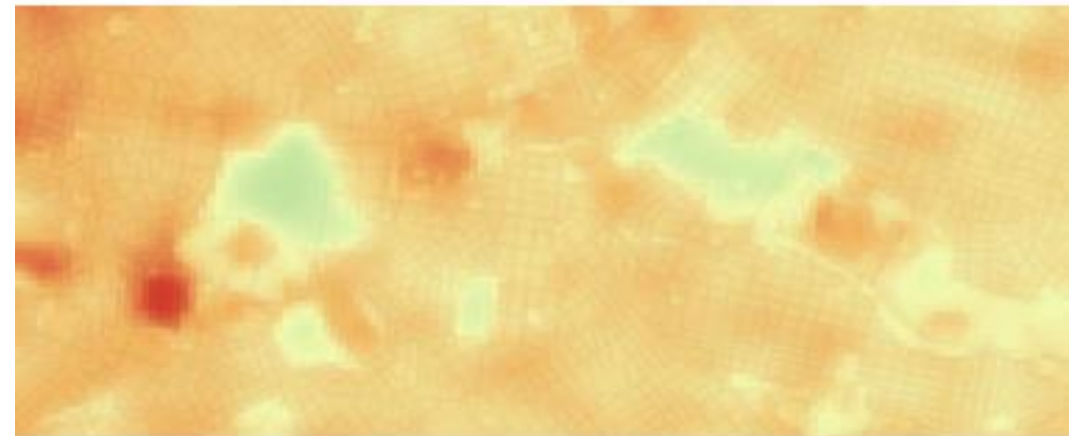
NSI 9. Surface Park Cool Island (SPCI) (what kind of parks?)

Surface Park Cool Island- SPCI) SPCI is the difference $\Delta T = T_u - T_p$

T_p is the average Land Surface Temperature (LST) in the park,

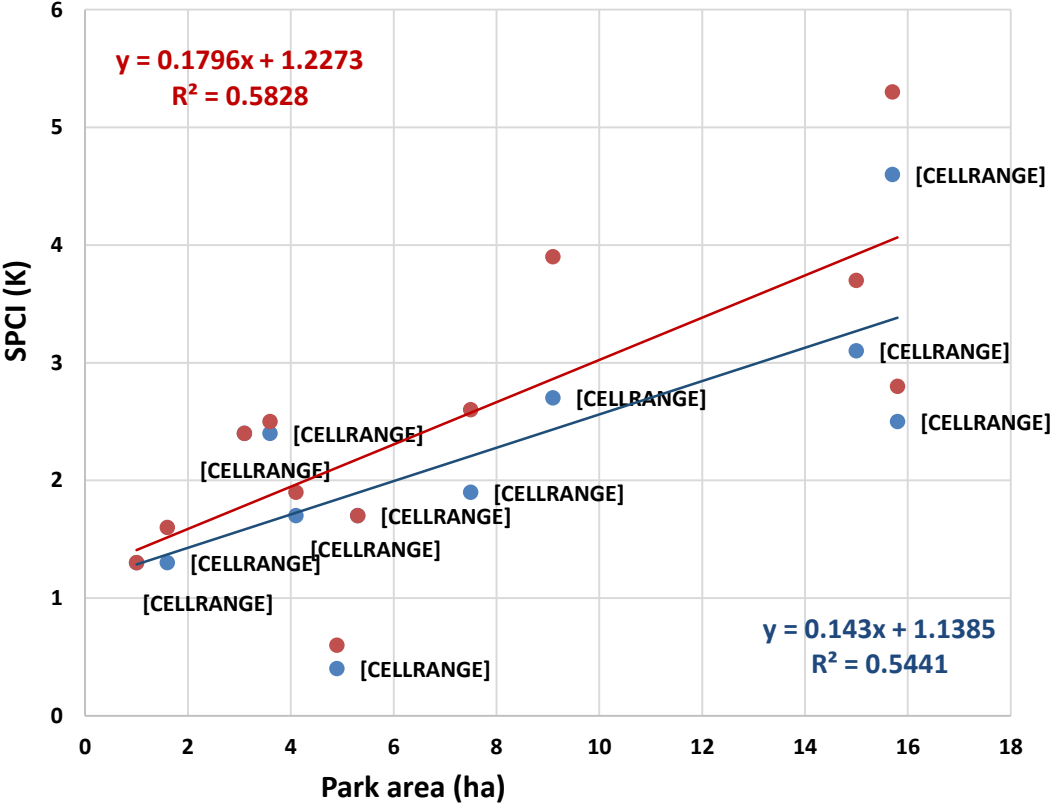
T_u the average Land Surface Temperature of the urban fabric around the park at a radius of 500 meters (excluding other parks or areas with water).

The 500 meters zones are depicted in purple.

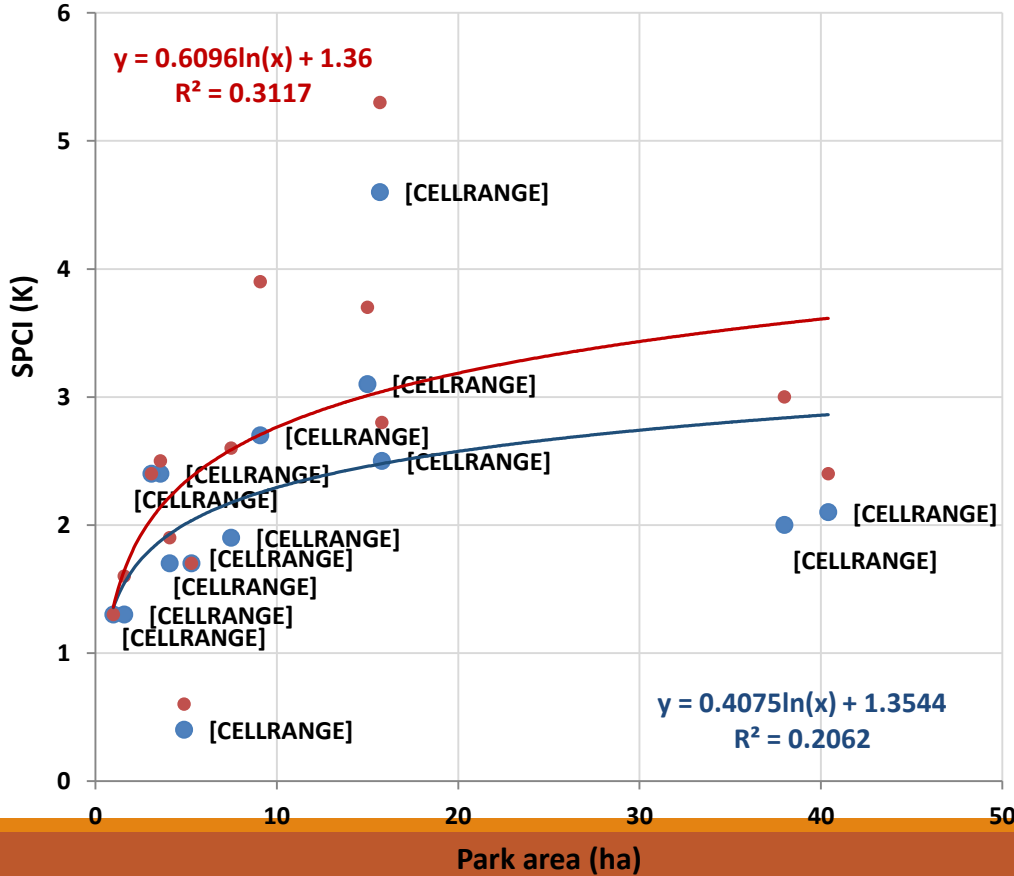


Impact of park area to SPCI: SPCI increases with increasing park size up to sizes around 20 ha and then becomes non correlated.
IMPORTANT TO DEVELOP MANY SMALL PARKS – URBAN ACUPUNCTURE

SPCI vs park area (parks up to 16ha)

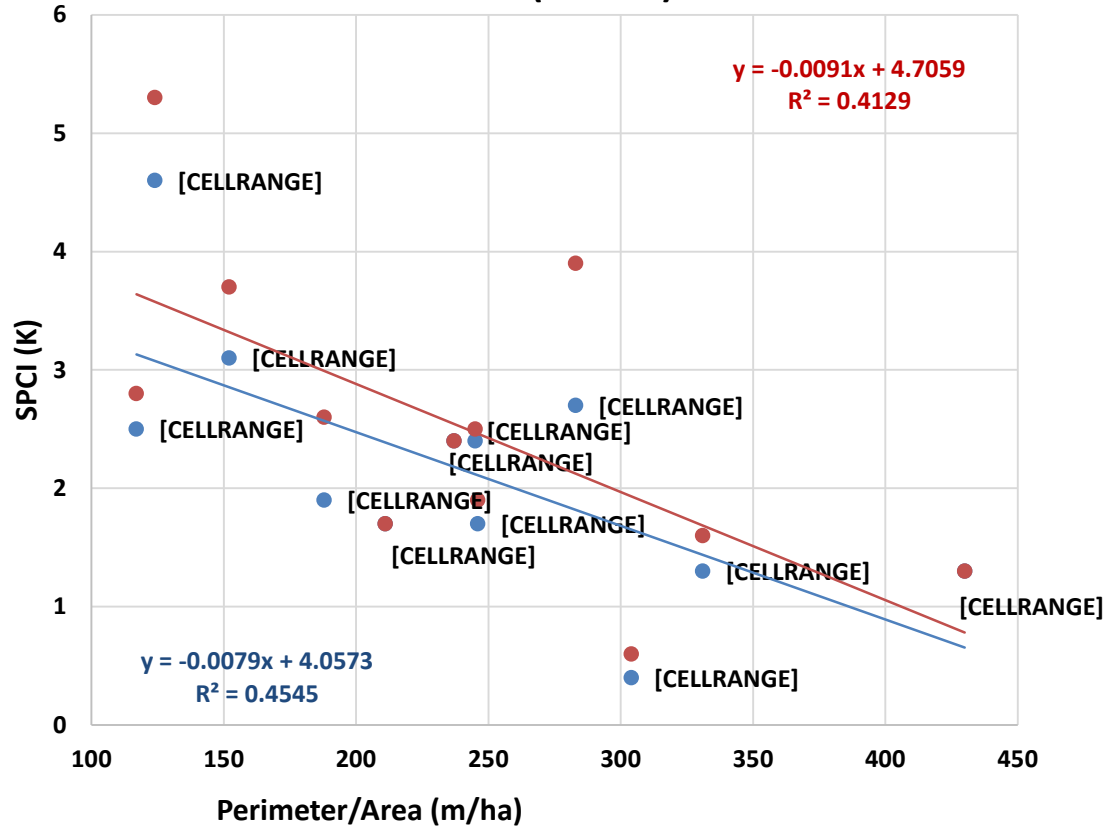


SPCI vs park area (all parks)

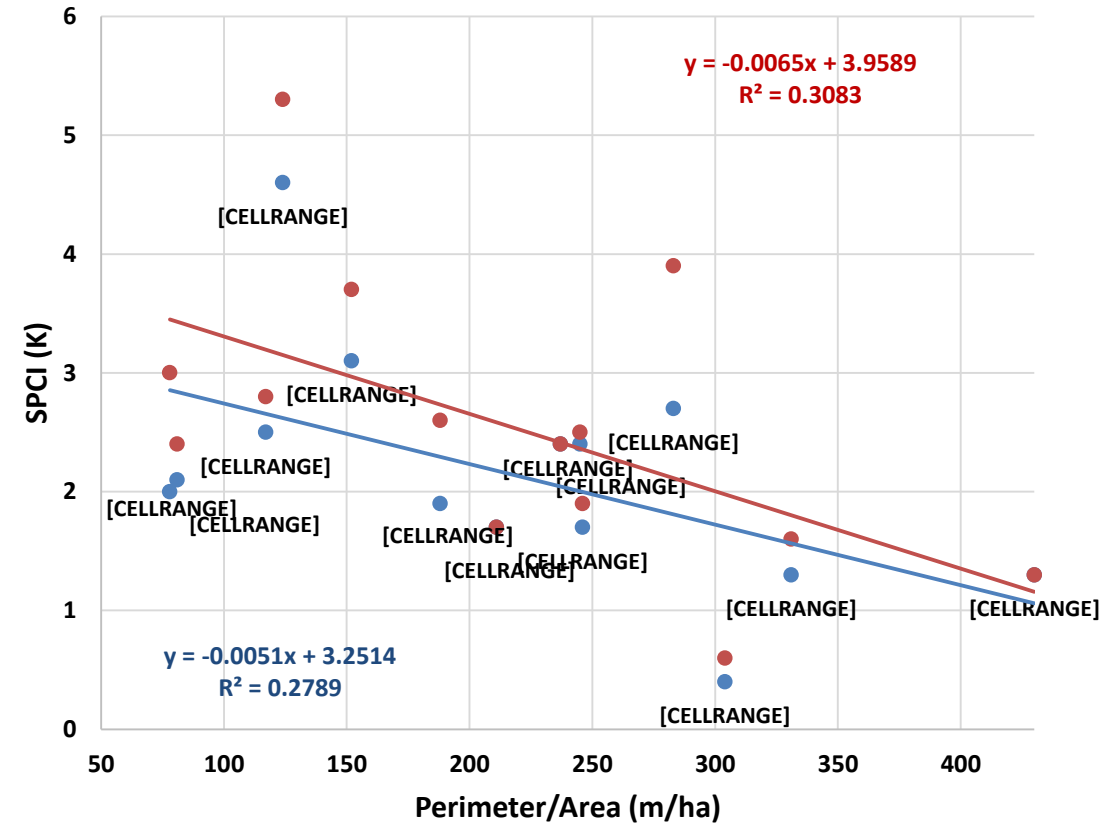


Impact of the shape of an urban park to SPCI

SPCI vs Park's Perimeter/Area
(<16ha)



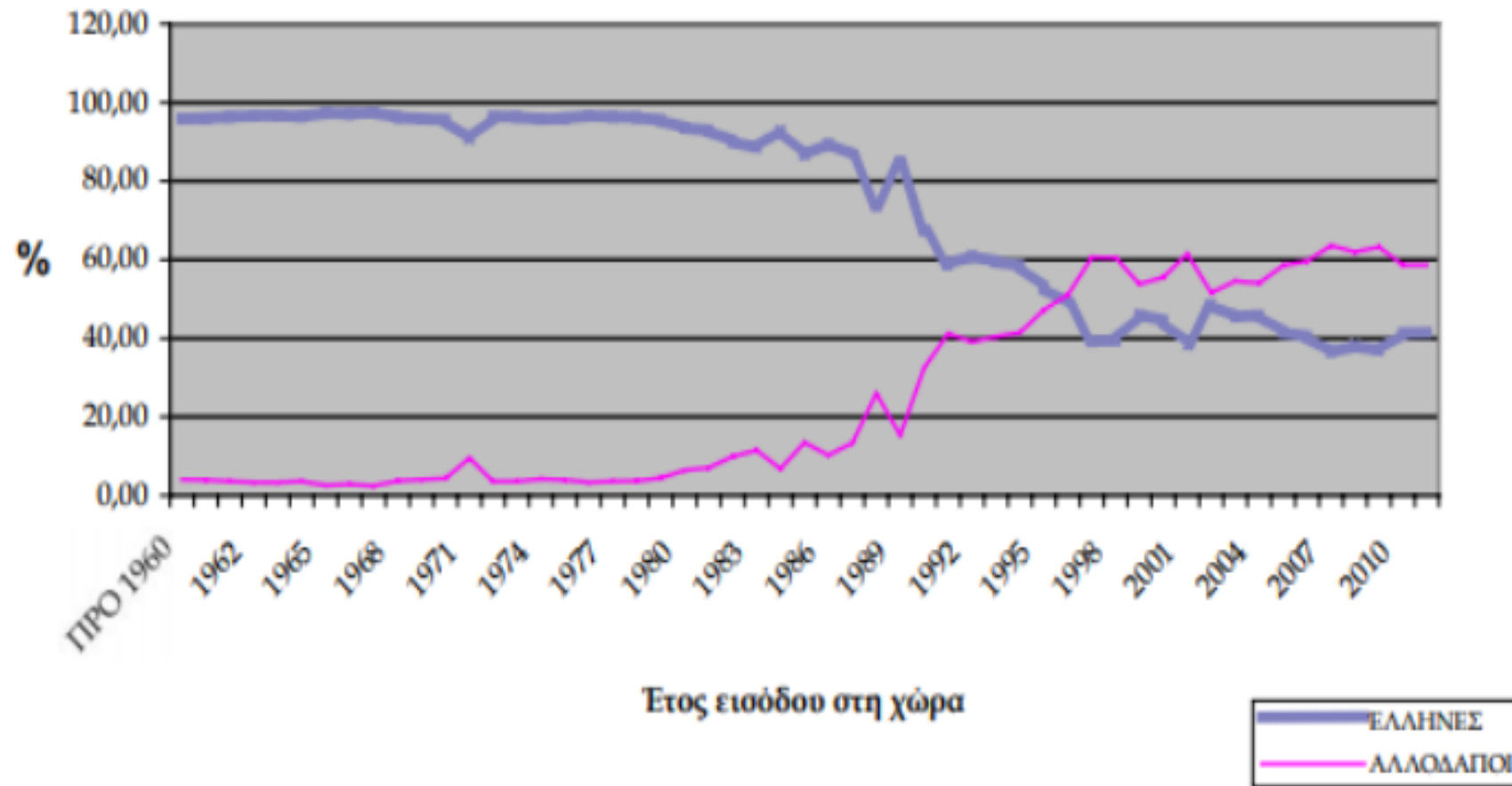
All parks

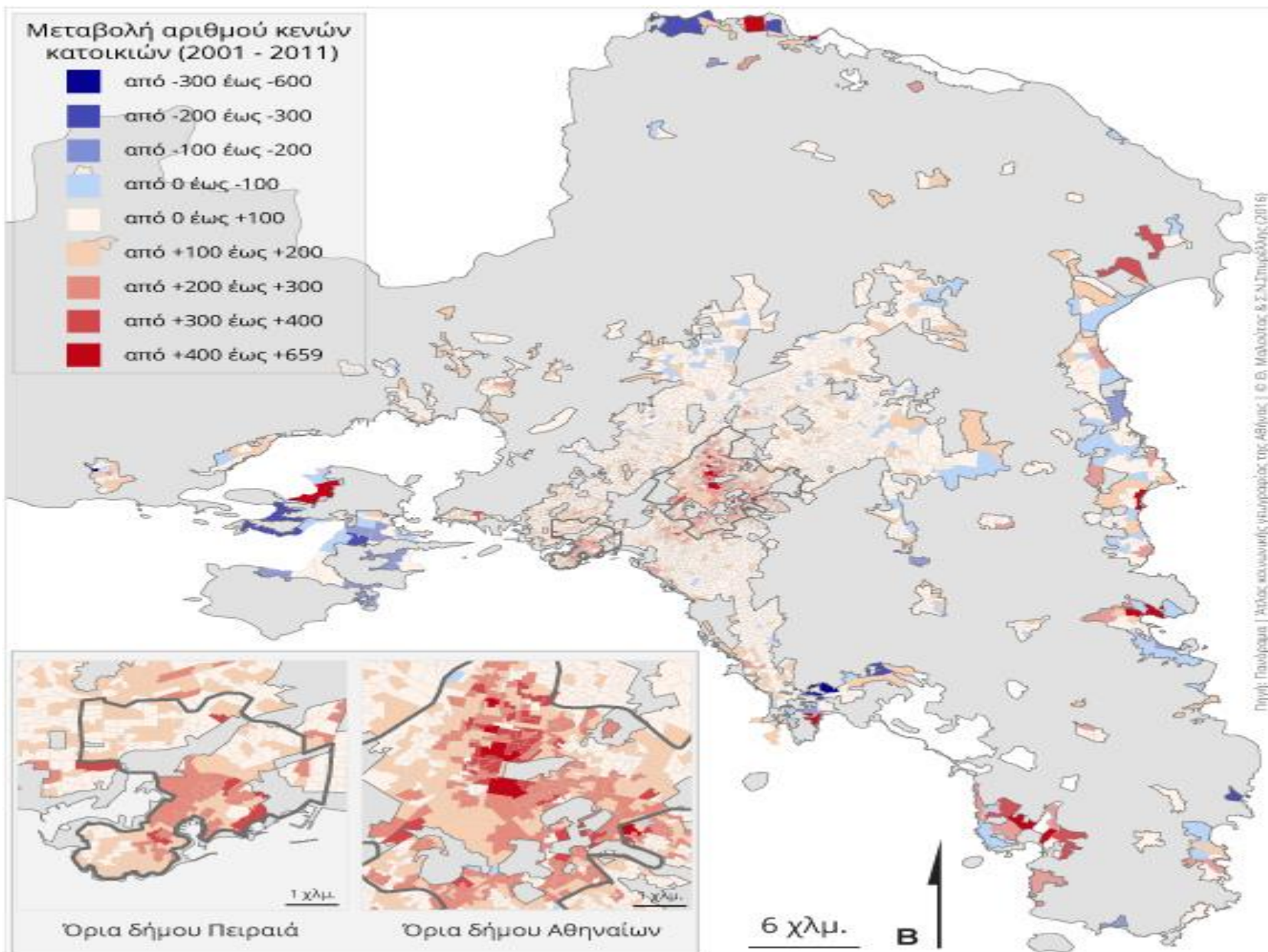


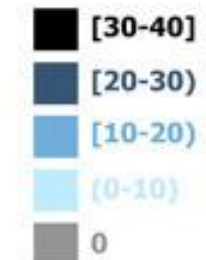
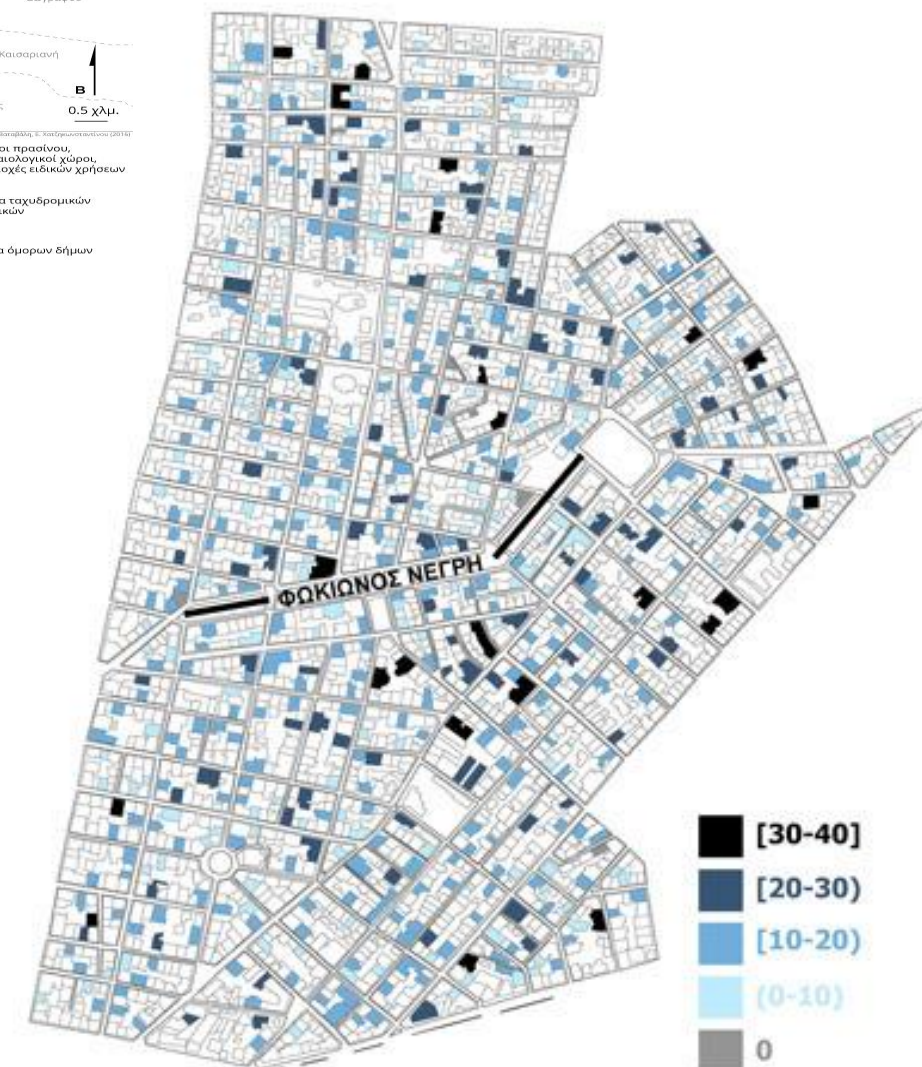
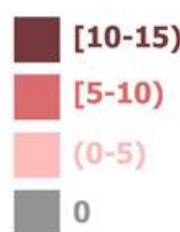
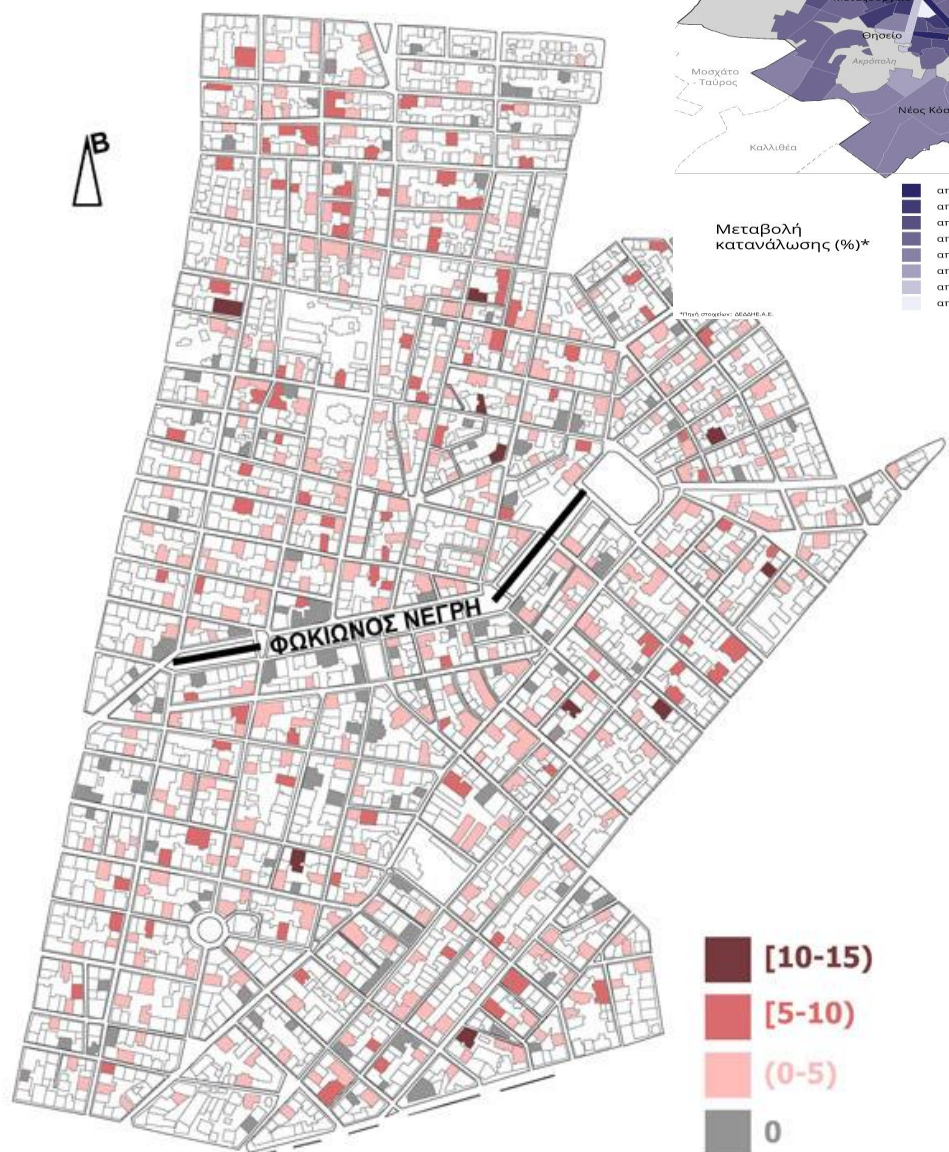
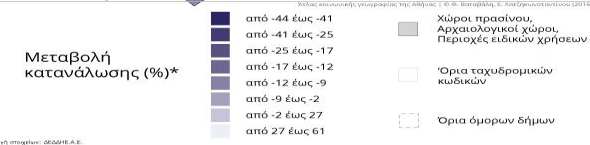
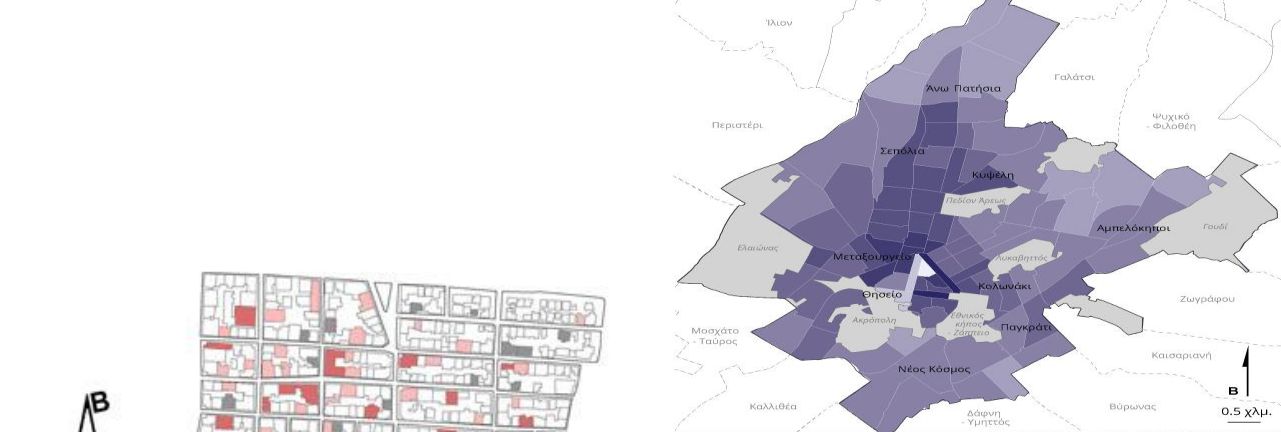
- The higher P/A, that is the more complex the shape of the park, the lower the SPCI.
- Complex shape → intrusion of building materials and anthropogenic heat.

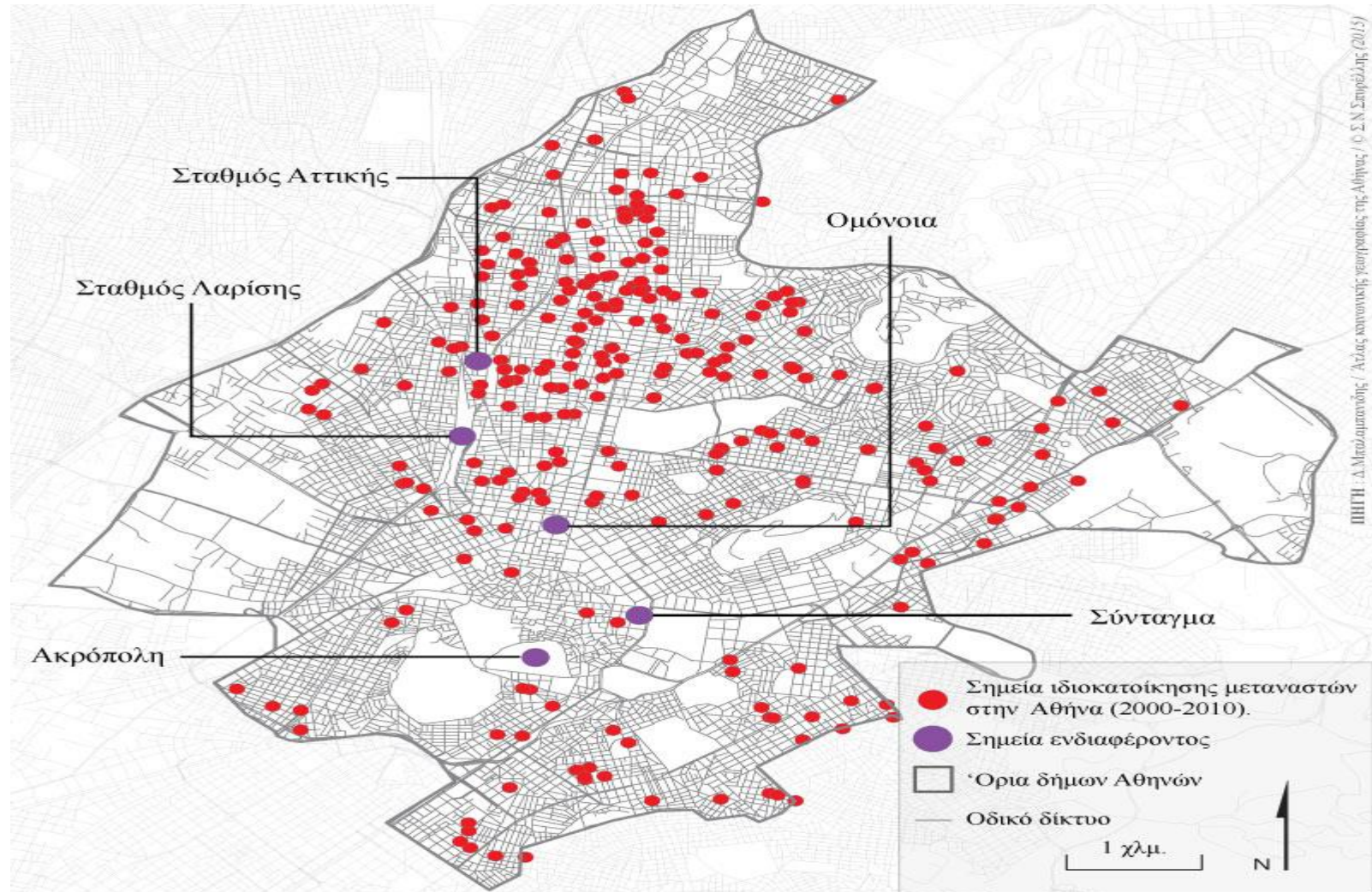
New comers to the city

Blue curve: Greek
Red curve: Foreigners



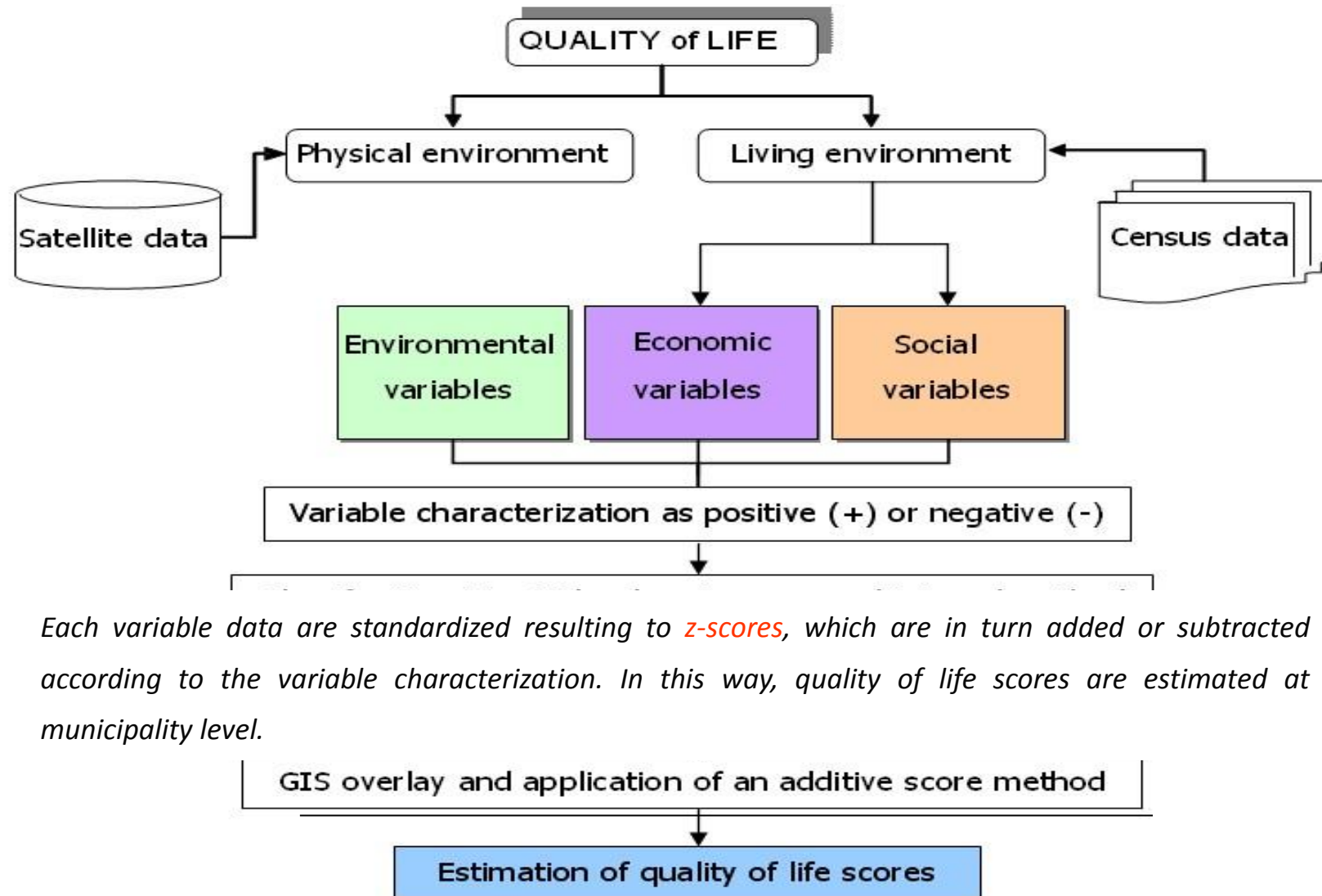




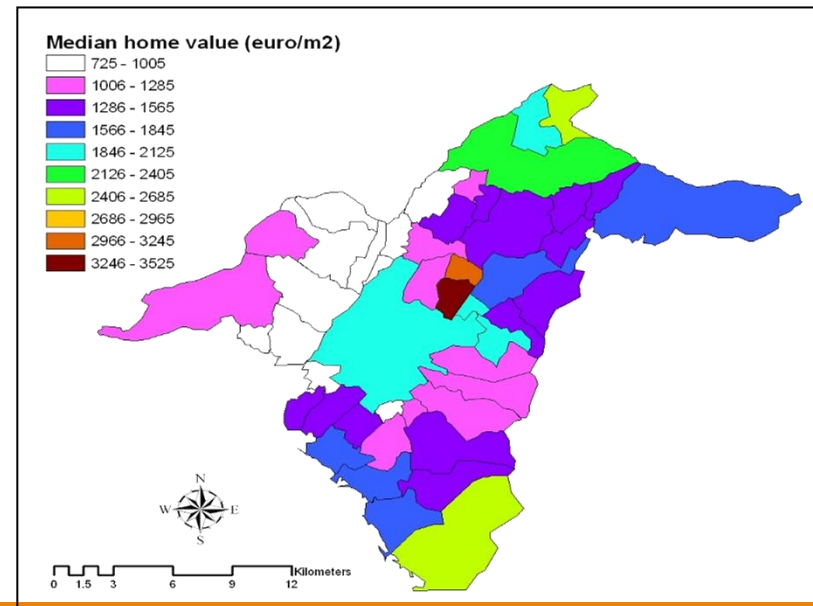
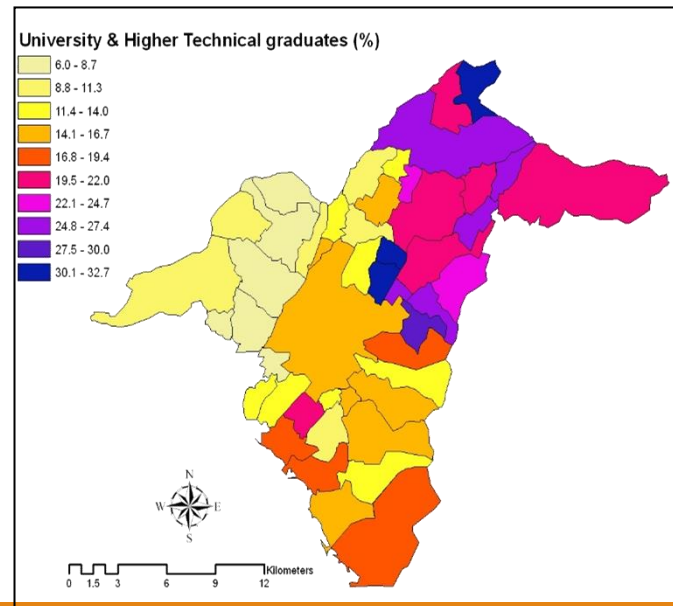
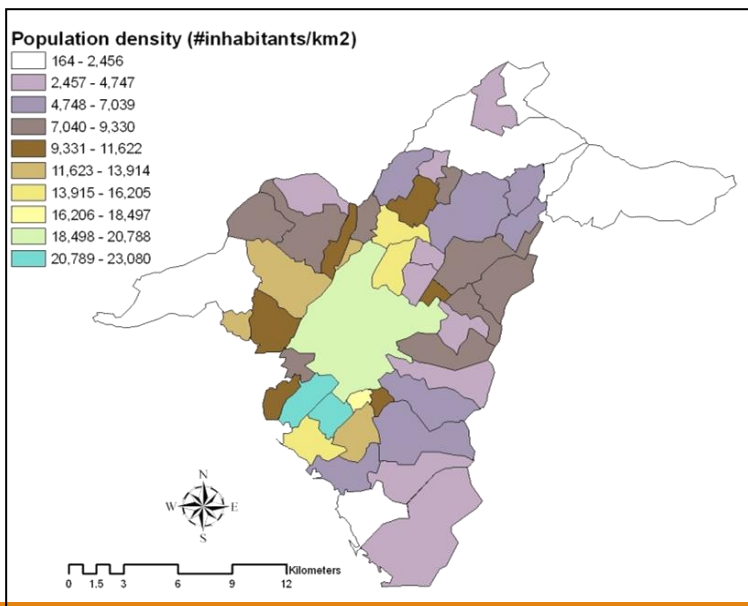
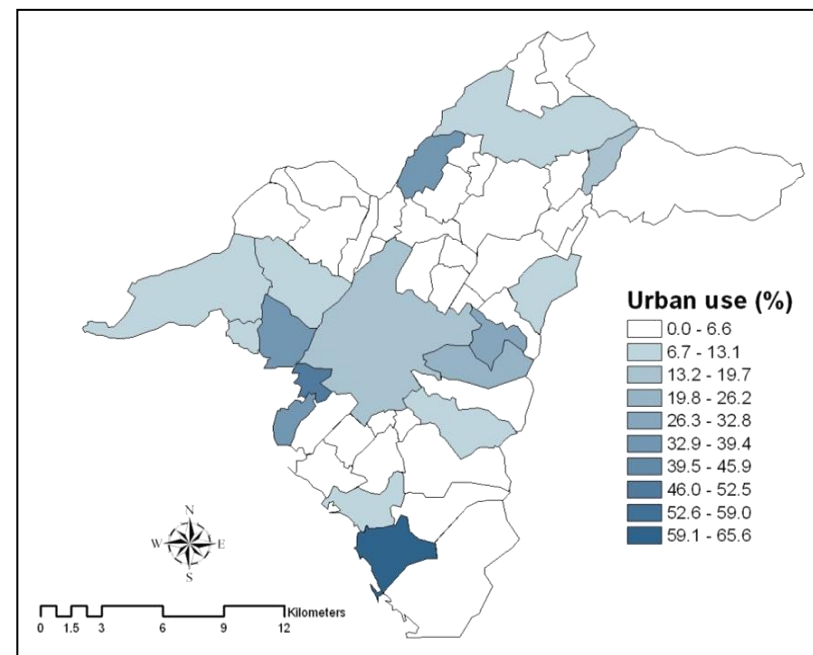
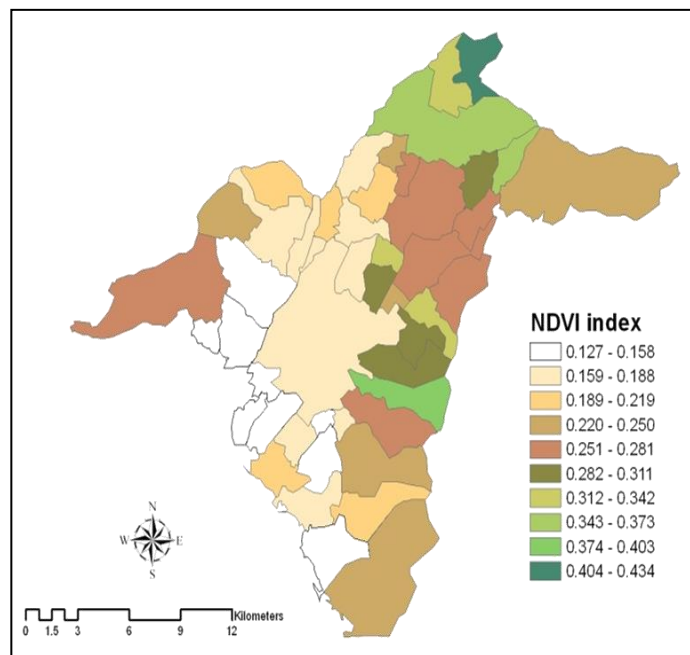
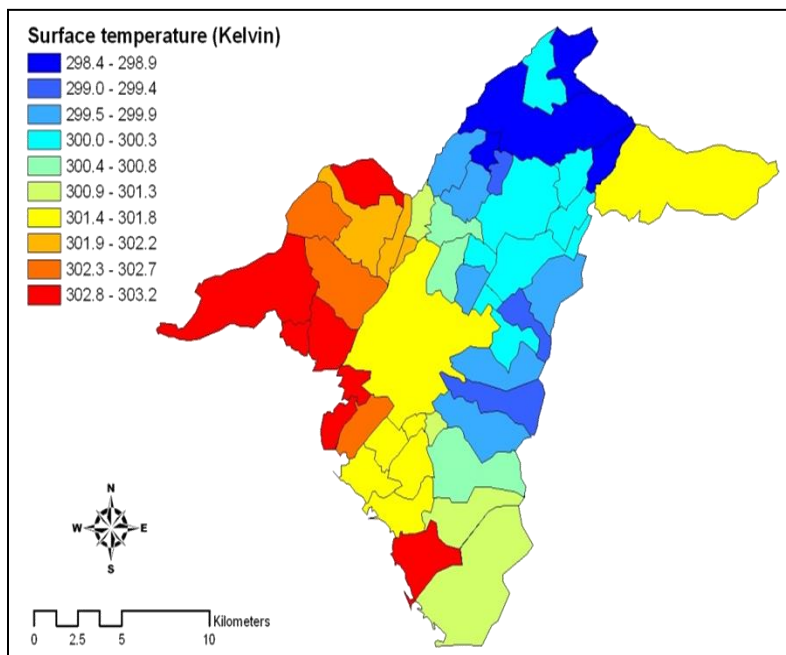


MONITORING THE CITY

NSI 10. Combine environmental, social and economic data

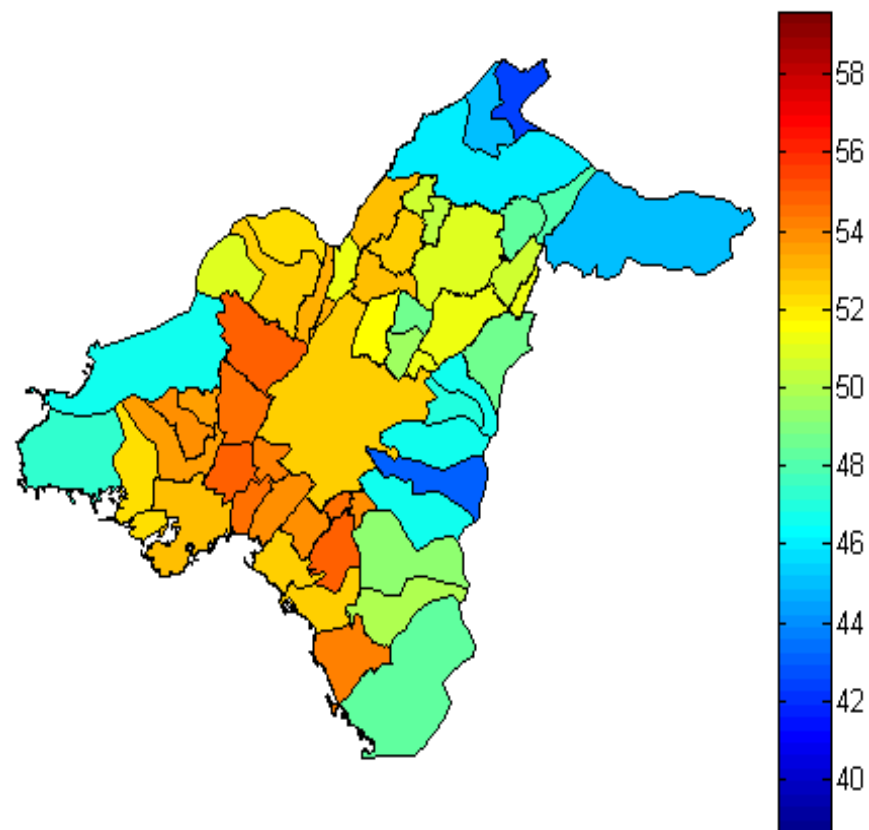


*Each variable data are standardized resulting to **z-scores**, which are in turn added or subtracted according to the variable characterization. In this way, quality of life scores are estimated at municipality level.*

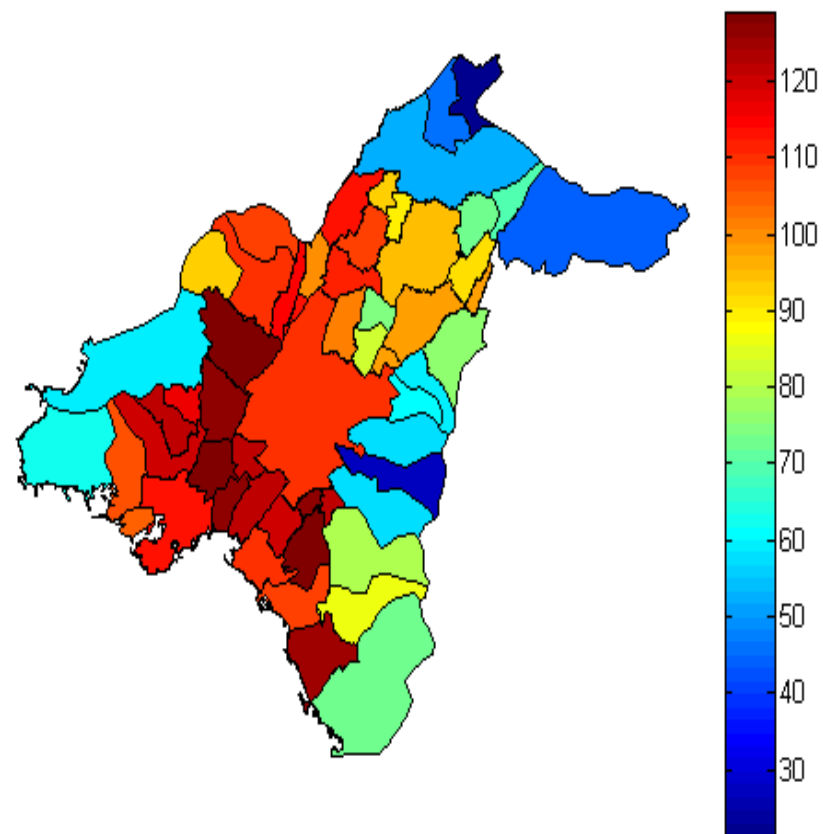


Urban use is defined as land cover reflecting industrial/commercial/transport units/mineral extraction sites/dump and construction sites.

PM 10



Mortality per 1000
inhabitants



QUALITY OF LIFE

