



## The ARSINOE project: Addressing extreme heatwaves in Athens

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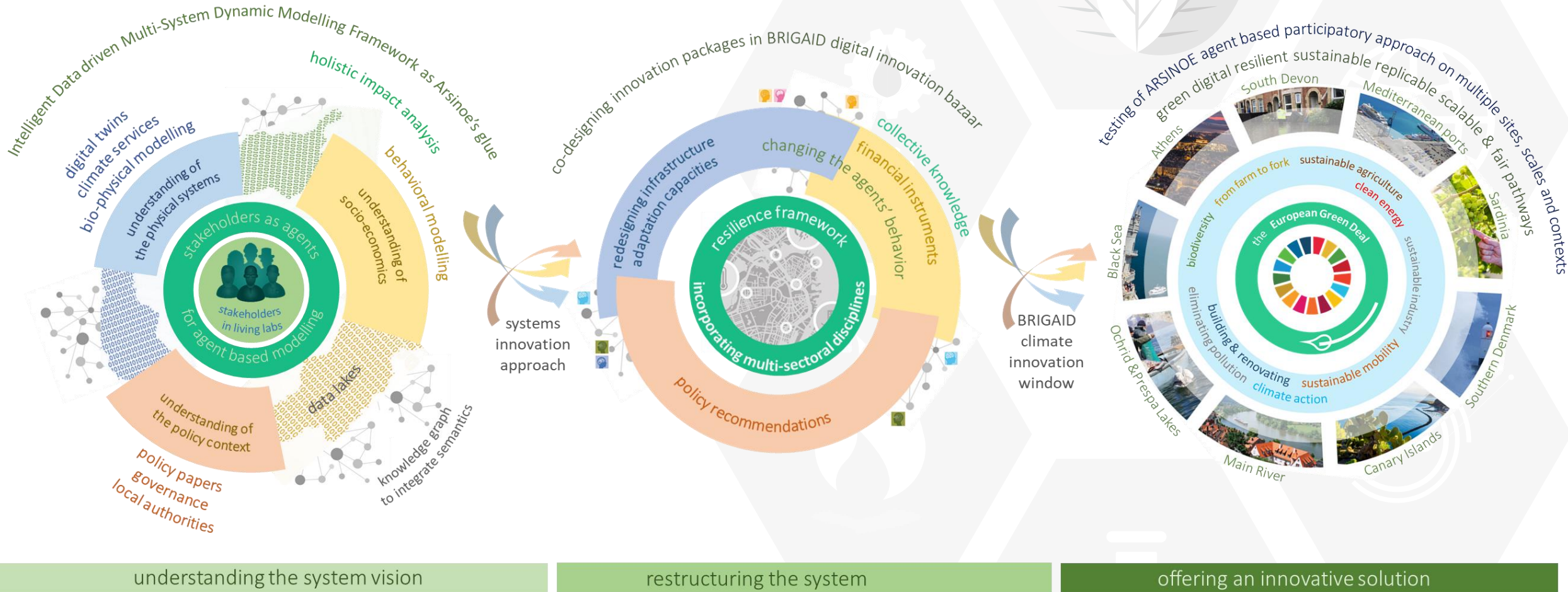
Open Training Session #6

Heat and Health: Building Resilience for a Hotter Future



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# ARSINOE methodological framework in a glimpse



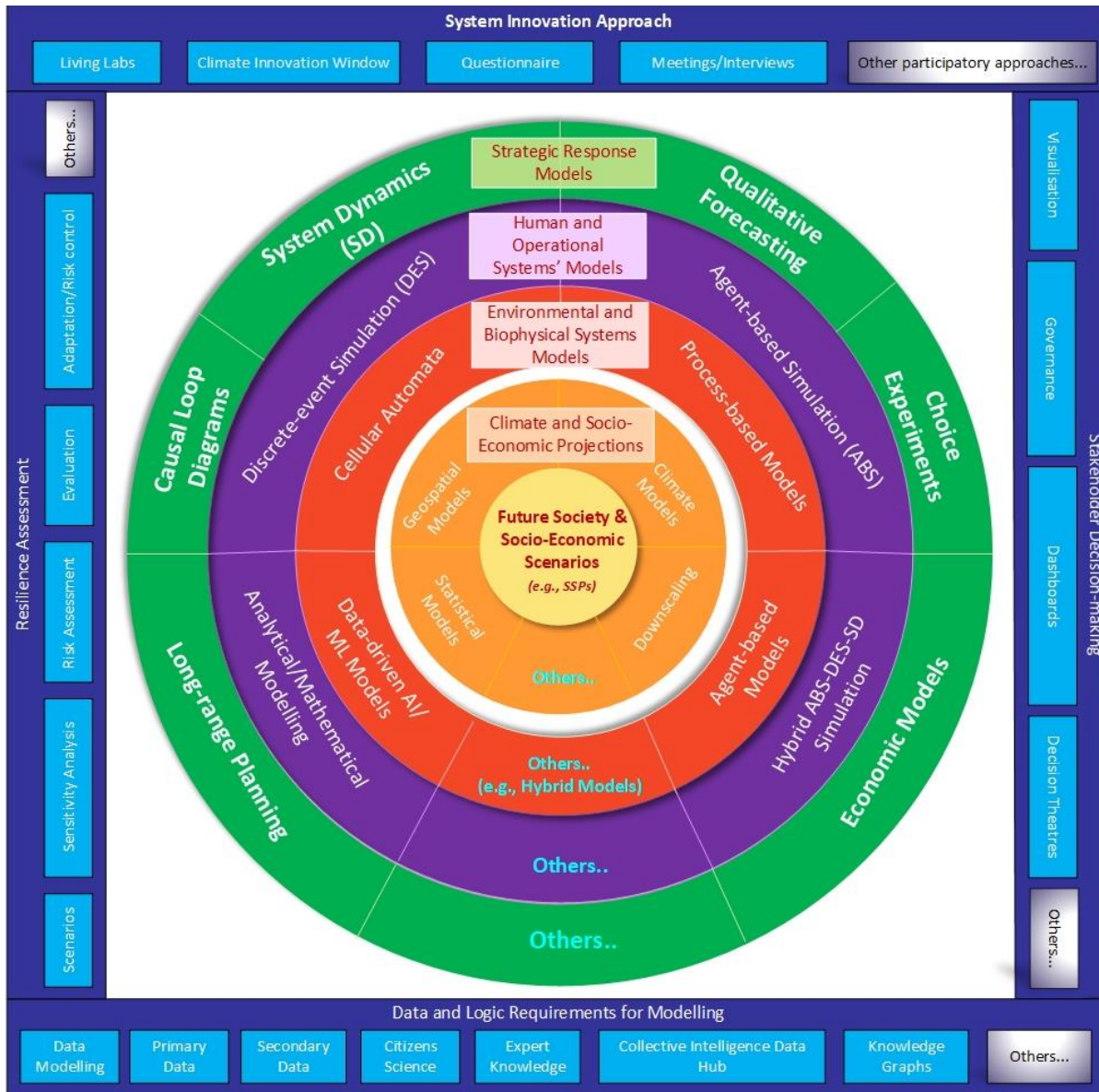


“Athens is becoming increasingly hot with significant impacts on health, society and the local economy. What is our vision for dealing, together, with this imminent and invisible threat?”





# The Resilience Wheel of ARSINOE for the Athens case study



tier 1 SSP1-2.6 and SSP3-7.0

tier 2 climatic parameters statistical downscaling

tier 3 Urban Heat Island  
biodiversity  
landscape fragmentation  
noise

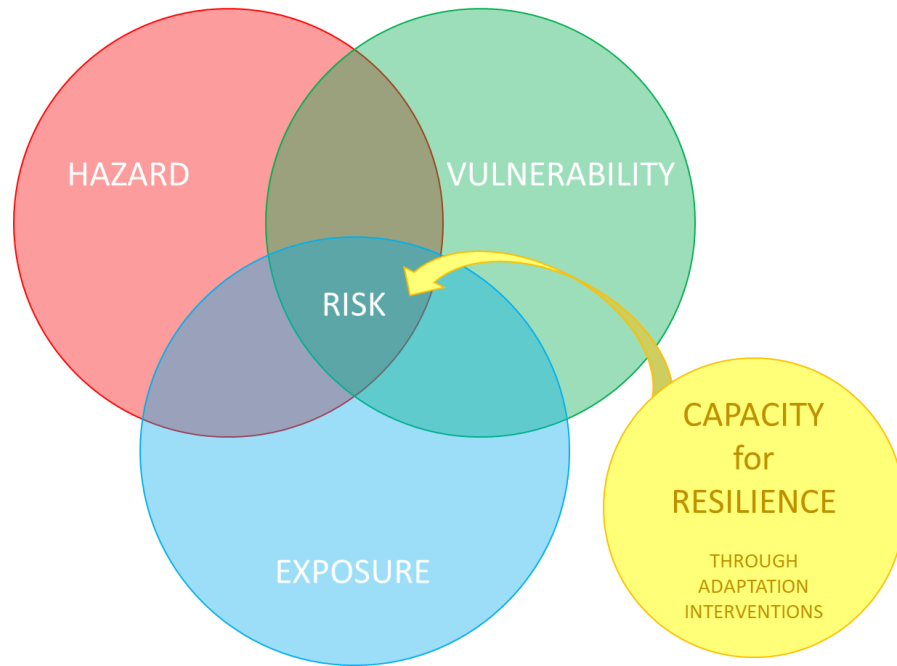
population density  
air quality  
socio-economic vulnerability

tier 4 heatwave crisis response tool

tier 5 blue & green infrastructure tool  
assessment of willingness to pay

# Resilience as a continuous risk mitigation exercise

Hazard x Vulnerability x Exposure



1	1	2
1	2	2
1	2	3

hazard maps

1	2	1
1	1	1
3	2	2

vulnerability maps

3	3	1
3	3	2
1	1	2

exposure maps

3	6	2
3	6	4
3	4	12

risk maps

applying interventions to decrease risk and increase resilience to the identified hotspots

3	4	2
3	4	4
3	4	4

# the long-term risk system for urban planning horizon interventions

$$\text{Risk} = \text{Hazard} \times \text{Vulnerability} \times \text{Exposure}$$

interventions for resilience



green & blue infrastructure for UHI mitigation  
response resources at heatwave crisis

primary hazards

vulnerabilities

exposures

risk

**heatwave**  
UHI by CNA  
average surface temperature  
calibrated against Copernicus

morbidity & mortality

animal  
plant species

**air pollution**  
NO<sub>2</sub>, NO, CO, O<sub>3</sub>, SO<sub>2</sub>, PM<sub>2.5</sub>,  
PM<sub>10</sub>, VOCs

impact on well-  
being

residents

**noise**

tourism  
decrease

workers

cascading hazards

**biodiversity loss**

energy  
consumption  
increase

businesses

**violence**

water  
consumption  
increase

tourists

identification of  
risk hotspots that  
need interventions  
for increasing  
resilience





## different risk systems at different time scales

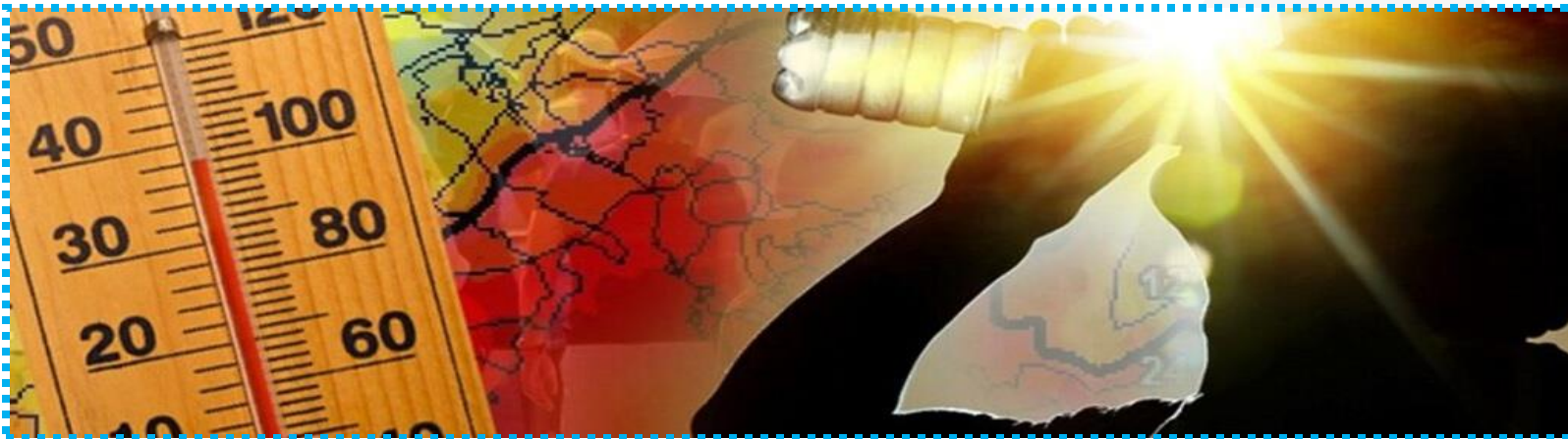
### long-term: urban planning horizon

how can we reduce the Urban Heat Island?

heatwave + air pollution

+biodiversity loss + noise

impact on health, well-being, tourism, economy



### short-term: immediate response horizon

how can we respond during the heatwave crisis?

heatwave + air pollution

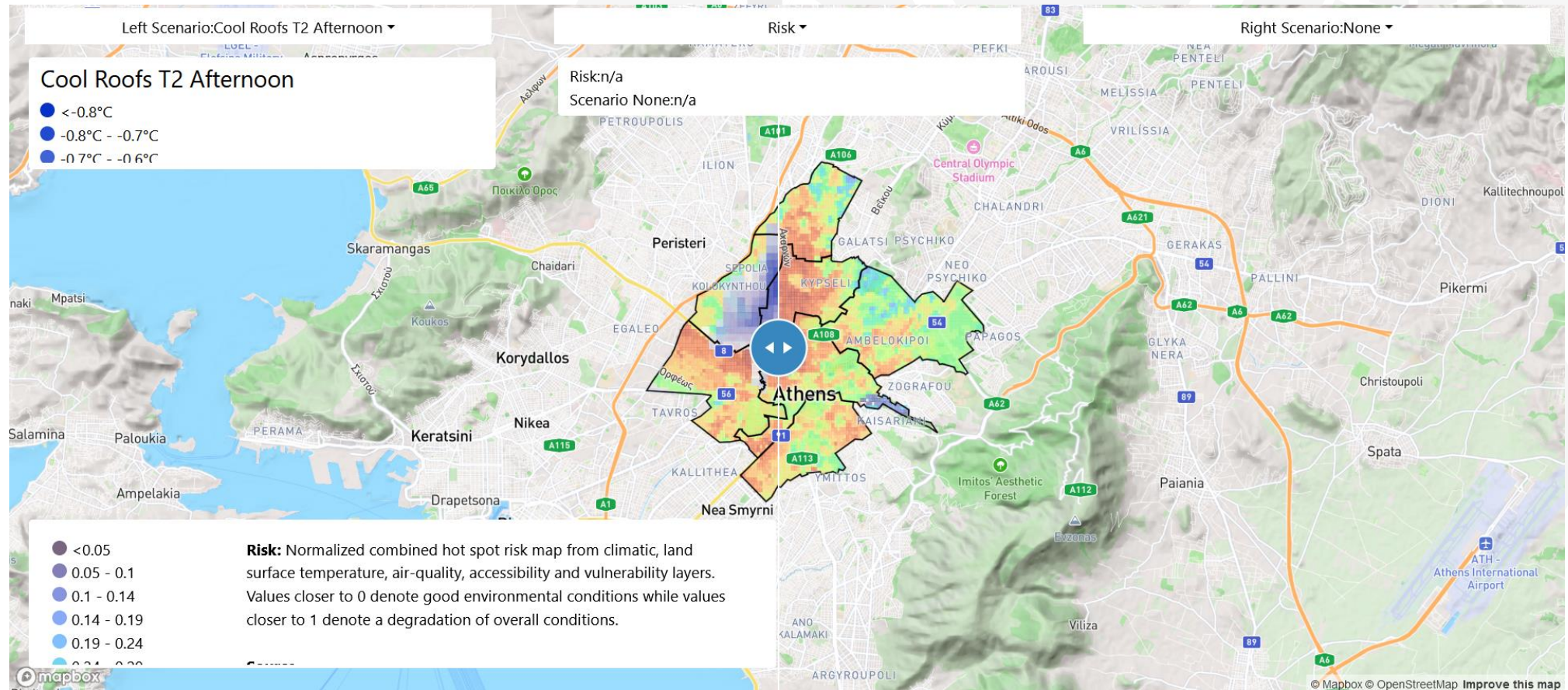
direct impact on human health  
and quality of life





## a supportive tool that

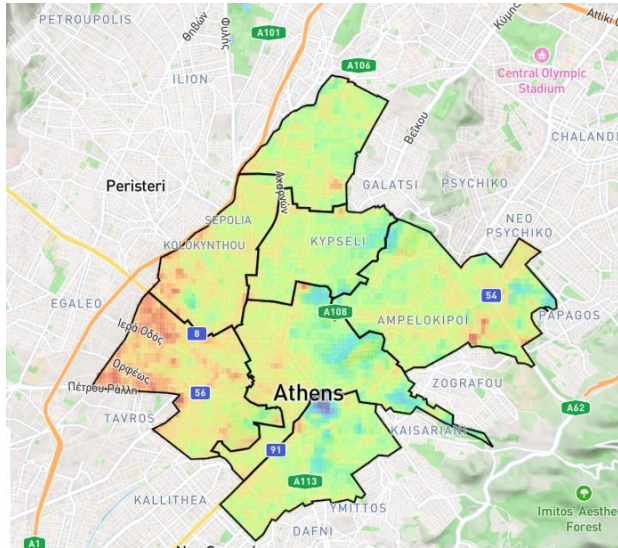
- integrates and visualizes all risk parameters
- prioritizes adaptation for Athens neighborhoods based on long-term risk
- assesses the relief achieved through a list of selected interventions



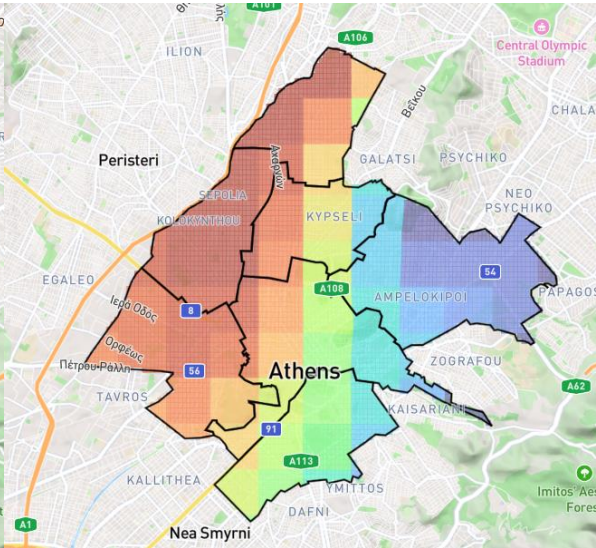


## integrated models

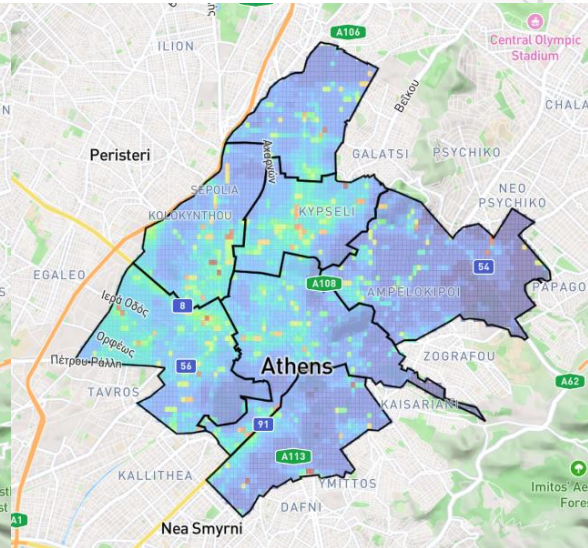
### land surface temperature



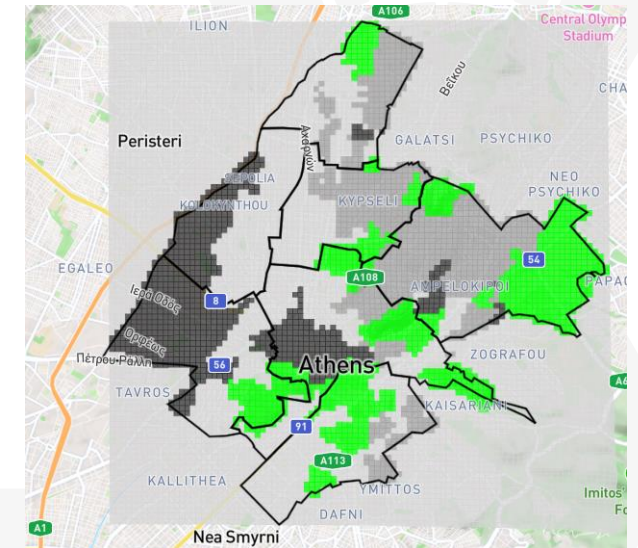
### heat index



### air quality



### biodiversity clusters



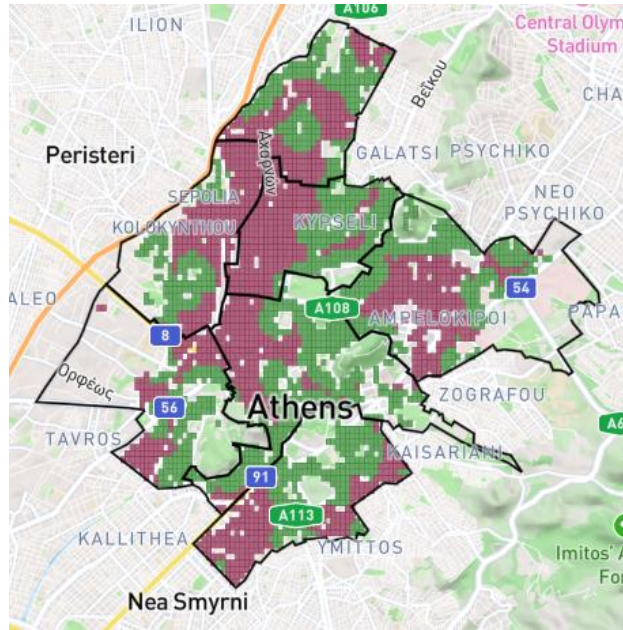
Varotsos, K. V., Dandou, A., Papangelis, G., Roukounakis, N., Kitsara, G., Tombrou, M., & Giannakopoulos, C. (2023). Using a new local high resolution daily gridded dataset for Attica to statistically downscale climate projections. *Climate Dynamics*, 60(9), 2931-2956.

Karl, M., Walker, S. E., Solberg, S., & Ramacher, M. O. (2019). The Eulerian urban dispersion model EPISODE–Part 2: Extensions to the source dispersion and photochemistry for EPISODE–CityChem v1. 2 and its application to the city of Hamburg. *Geoscientific Model Development*, 12(8), 3357-3399.

Ziliaskopoulos, K., & Laspidou, C. (2024). Using remote-sensing and citizen-science data to assess urban biodiversity for sustainable cityscapes: the case study of Athens, Greece. *Landscape Ecology*, 39(2), 9.

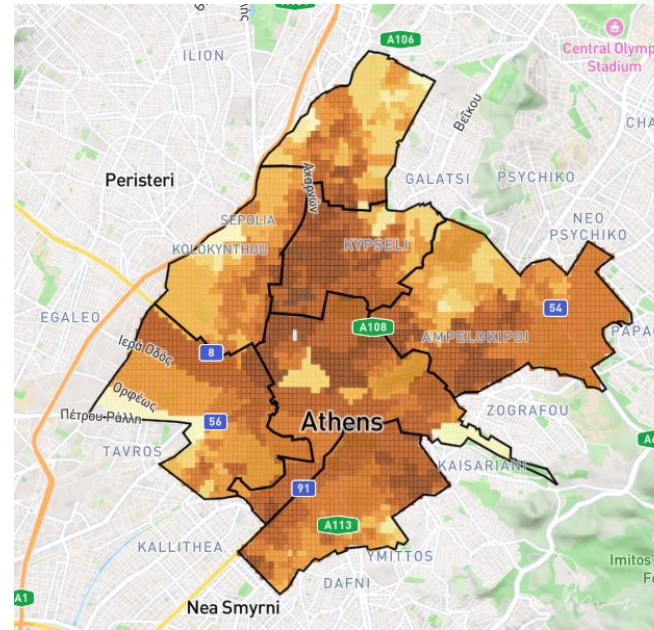


## integrated models



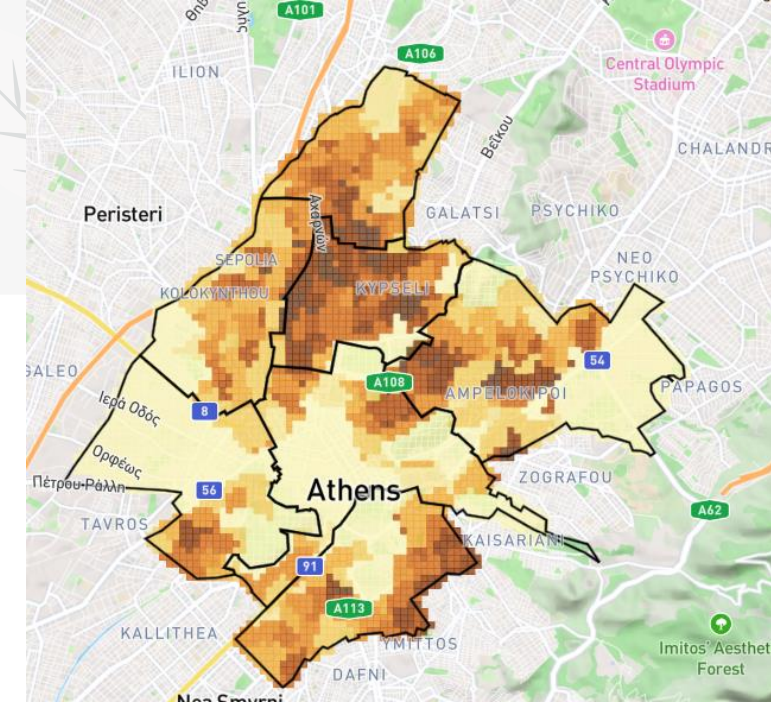
### accessibility to green

N. Votsi, G. Papangelis, K.V. Varotsos, E. Athanasopoulou, P. Koutsantoni, A. Karali, D. Karagianis, P. Sismanidis, C.T. Kiranoudis, I. Keramitsoglou, C. Giannakopoulos, E. Gerasopoulos, *A multi-faceted, integrated methodological approach to identify hotspots of combined urban environmental pressures in the climate change context*, Euro-Mediterranean Journal for Environmental Integration (EMJE, © 2025 Springer Nature): Accepted for publishing



### combined vulnerability

- elderly
- retired
- living in houses built before 1980
- living alone
- renting
- living in houses smaller than 60 sq m
- unemployed
- immigrants from low-income countries



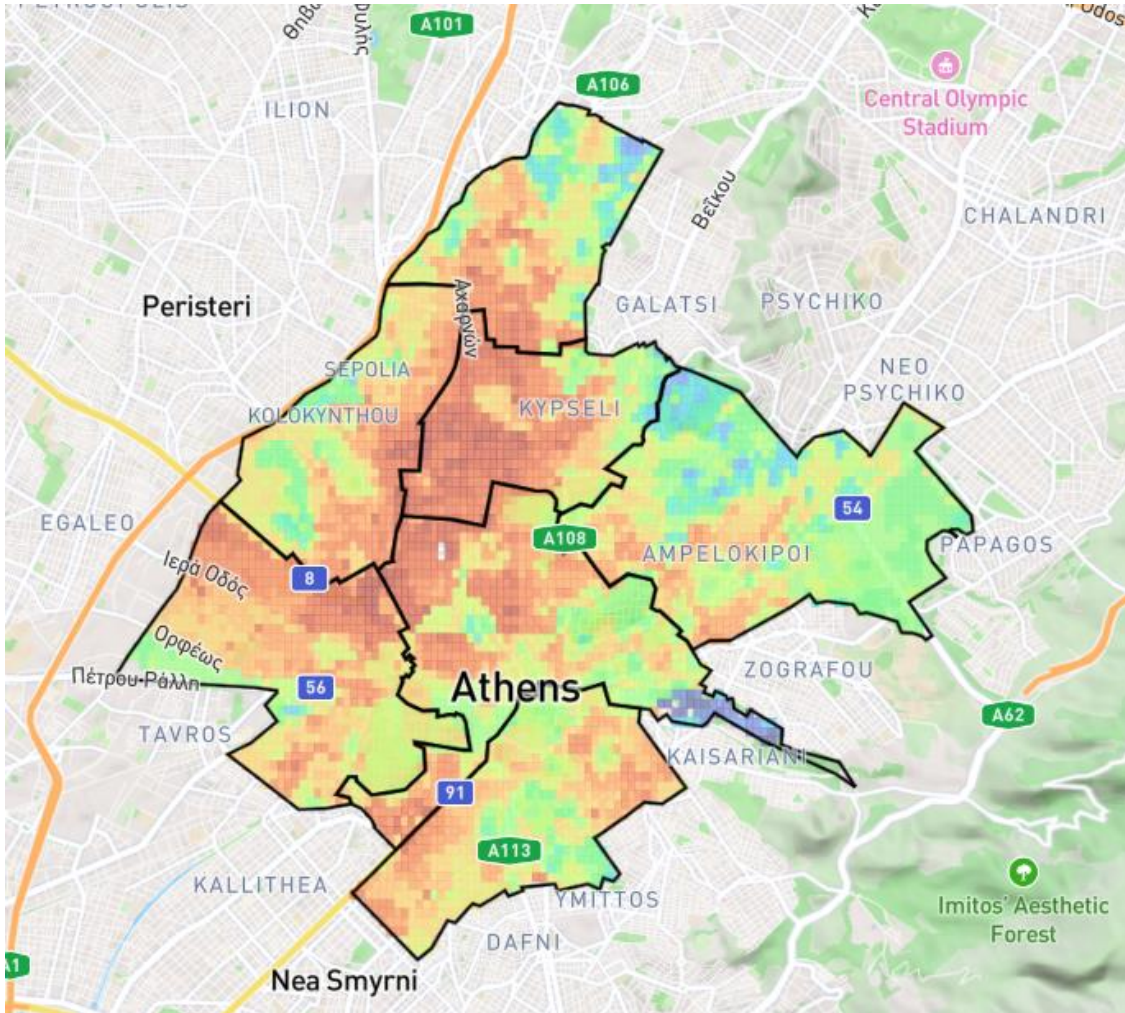
### population density

Ziliaskopoulos, K., Petropoulos, C., & Laspidou, C. (2024). *Quantifying and Mapping Vulnerability to Extreme Heat Using Socio-Economic Factors at the National, Regional and Local Level.*



## integrated models

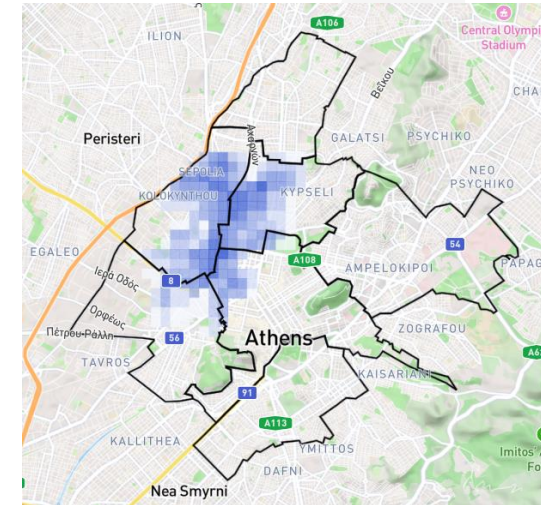
### heatwave risk



## urban planning horizon

### interventions tested:

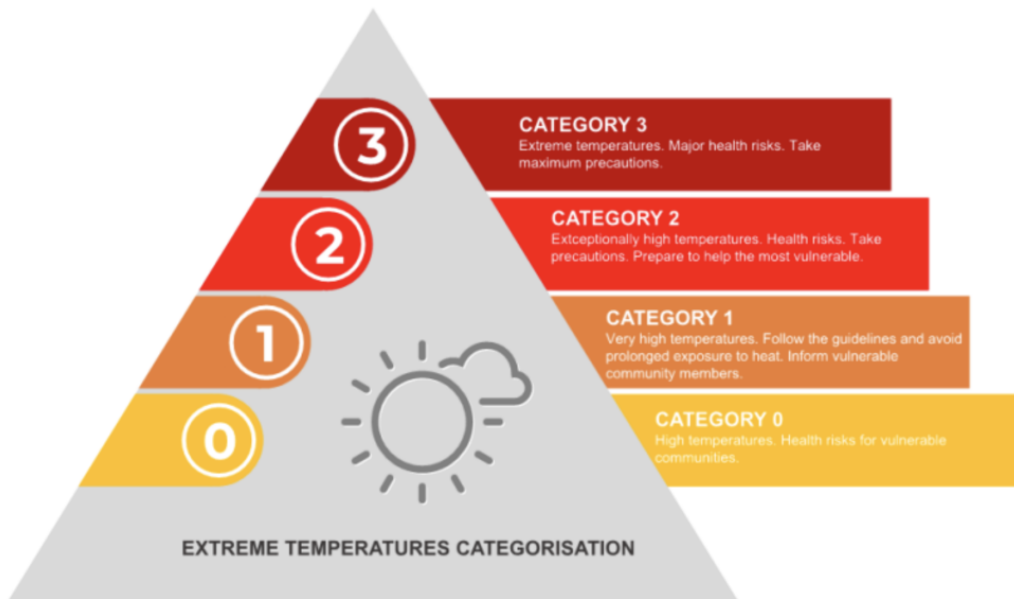
- cool roofs and cool streets
- green roofs and urban greening
- green roofs and urban trees



N. Votsi, G. Papangelis, K.V. Varotsos, E. Athanasopoulou, P. Koutsantoni, A. Karali, D. Karagianis, P. Sismanidis, C.T. Kiranoudis, I. Keramitsoglou, C. Giannakopoulos, E. Gerasopoulos, *A multi-faceted, integrated methodological approach to identify hotspots of combined urban environmental pressures in the climate change context*, Euro-Mediterranean Journal for Environmental Integration (EMJE, © 2025 Springer Nature): Accepted for publishing

a supportive ABM tool  
for immediate response that:

- informs, supports the coordination, consults the involved actors on the high priority intervention spots and the type of support needed
- integrates existing heatwave categorizations
- activates responses gradually as a function of the heatwave category
- distinguishes the heatwaves hazard from the wildfires hazard
- enables a digital twin and early warning tool



resources and corresponding services:

- guidance • shading • cooling • drinking water •
- animal support • first aid • medical care •

Municipality of Athens and other Municipalities

municipal parks, friendship clubs, protection centres for the elderly, municipal health centers, drinking water distribution, helpline, Athens Municipal Homeless Shelter, health workers or volunteers, Extrema Global, Cool of Athens website, free WiFi spots, animal feeders, guidelines in Metro stations

Region of Attica

regional parks, air-conditioned spaces, announcements on electronic boards

Red Cross

first aid trucks, Red Cross centers, shading kiosks, home assistance, water bottle distribution, volunteers' app

Ministry of Civil Protection

notifications, website with heatwave guidelines

Ministry of Labor and Social Security

instructions for working from home, restriction of outdoor work

Ministry of Health

circular note on extreme heatwaves, primary care structures, hospitals, connection with air pollution





## Singular Ribbon

lightweight linear structure of channels for a continuous strip of vegetation through hydroponics

- temperature decrease due to shade & evapotranspiration
- positive impact on biodiversity

## Tiny Forest in Athens

fast-growing native woodland, typically made up of 600 trees planted in a tennis-court-sized plot of 200m<sup>2</sup>

- connect people with nature
- mitigate impacts of heat stress
- enhance urban biodiversity



# the ARSINOE team for Athens case study supportive tools



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# THANK YOU



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