4.4. Urban Adaptation Strategies

From City to Block: a multi-scale analysis to improve outdoor space

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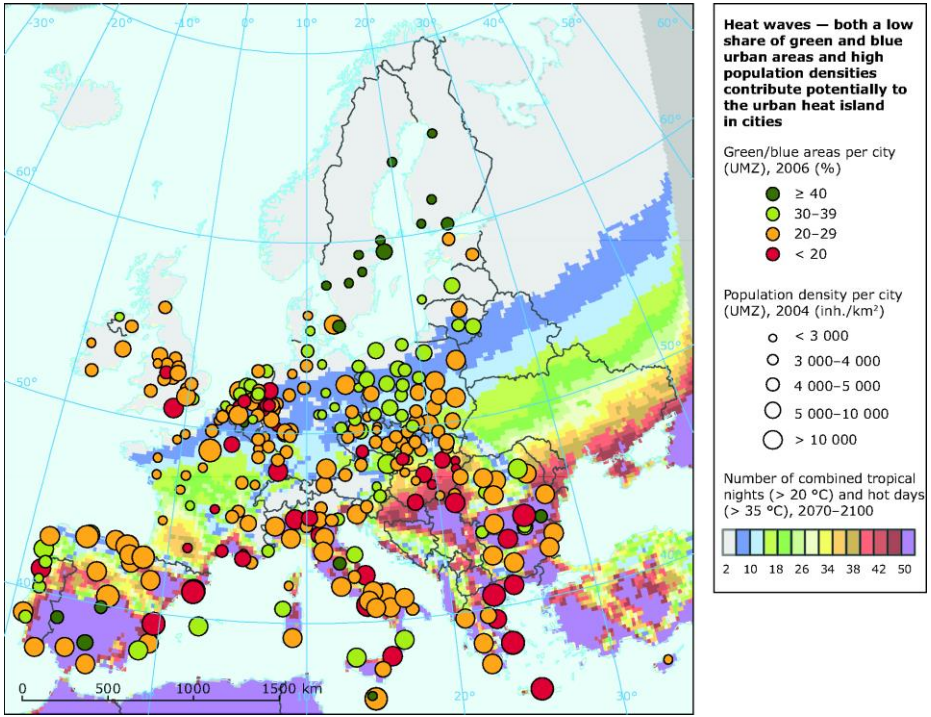
INTRODUCTION: Climate Emergency

Climate change is linked with increased climate variability, leading to extreme events, [1] such as the June 2019 European heatwave [2]. Additionally, the modification of land surfaces in urban areas leads to the urban heat island effect (UHI) – it exacerbates the impact of heatwaves in cities, such as heat-related mortality [3].

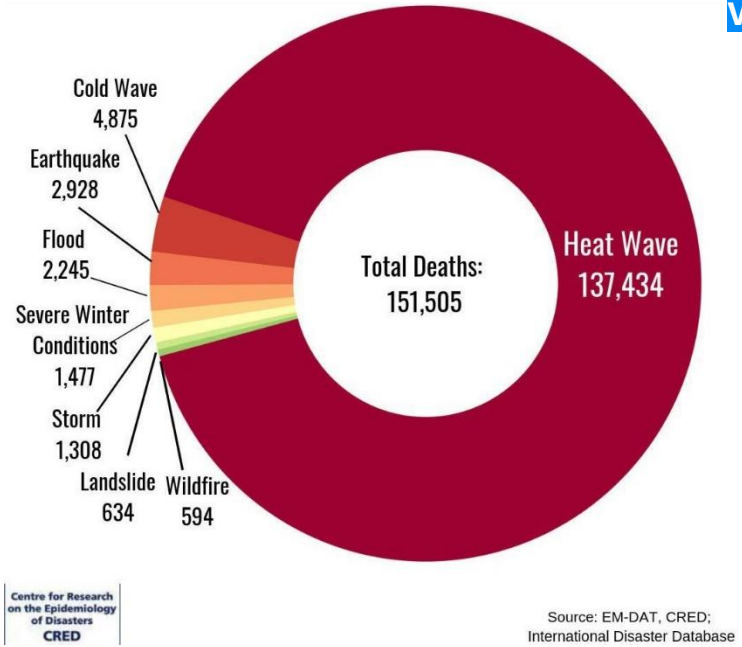


[1] IPCC, 2012 – Field, C.B., Barros, V., Stocker, T.F., Qin, D., DJ Dokken, D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.K., Allen, S.K., Tignor, M., and Midgley, P.M. (Eds.) Cambridge University Press, 582 pp.

[2] European State of the Climate 2019, Copernicus Climate Change Service, Full report: *climate.copernicus.eu/ESOTC/2019*

[3] Ward, K., Steffen Lauf, S., Kleinschmit, B., Endlicher, W.(2016) Heatwaves and urban heat islands in Europe: A review of relevant drivers. In: *Science of the Total Environment,* 569–570, https://doi.org/10.1016/j.scitotenv.2016.06.119.

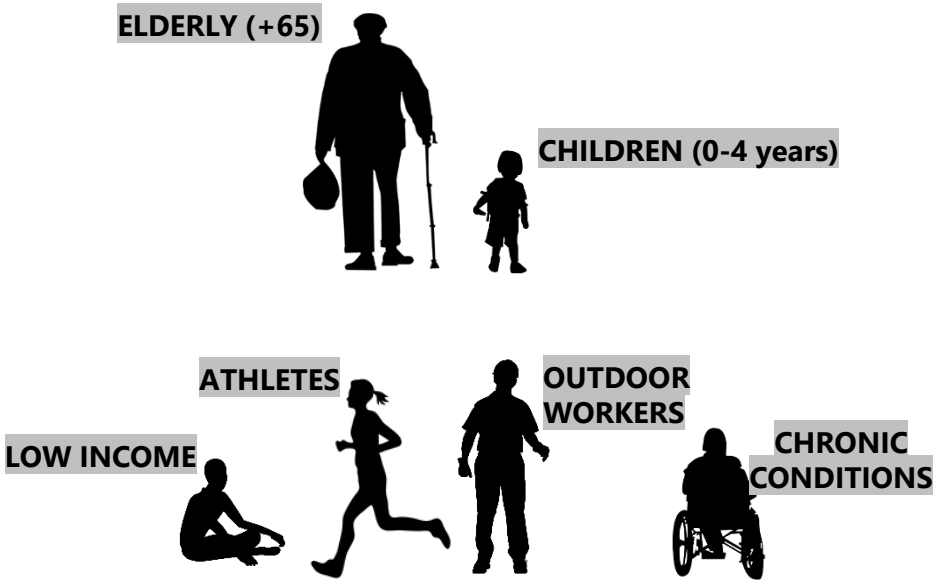
DEATH TOLLS IN EUROPE BY DISASTER TYPE 1995-2018



EEA, CRED EM-DAT file, 2018

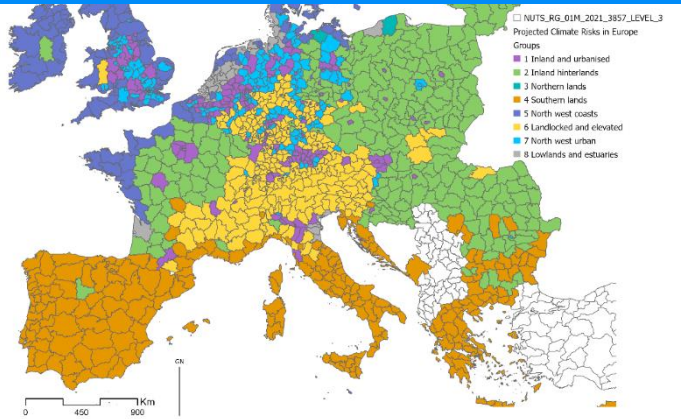
- The increased onset of heat-related fatalities makes a compelling case for early adaptation.

VULNERABLE GROUPS:



INTRODUCTION: Decreased Liveability Index

- European cities have to cope with **extreme heat** due to the Urban Heat Island effect (UHI), human activity, and intensified **heat waves** as well as **heavier storm events** AND address inclusion and belonging in recovery plans.
- The Covid-19 crisis and severe lockdown measures in many countries led to **decreased liveability** index worldwide (EIU, 2021)
- The crisis also created a rediscovered appreciation for public spaces by citizens, and prompted local administrators to take it as an **opportunity** to "build back better" (UN-Habitat, 2021)



Climate risk typology of NUTS3 regions in Europe
Source: H2020 RESIN Project, EEA (2020)
https://www.eea.europa.eu/legal/copyright. Copyright holder: EC, EA

Water square in Rotterdam-NL.

2015 Heatwave in Bordeaux-FR.

Empty piazza in 2020, Milan-IT.

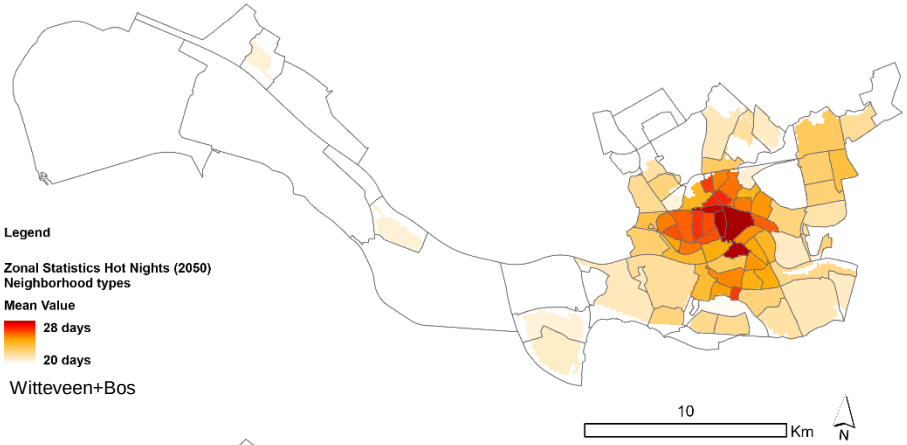
INTRODUCTION: What cities can do?

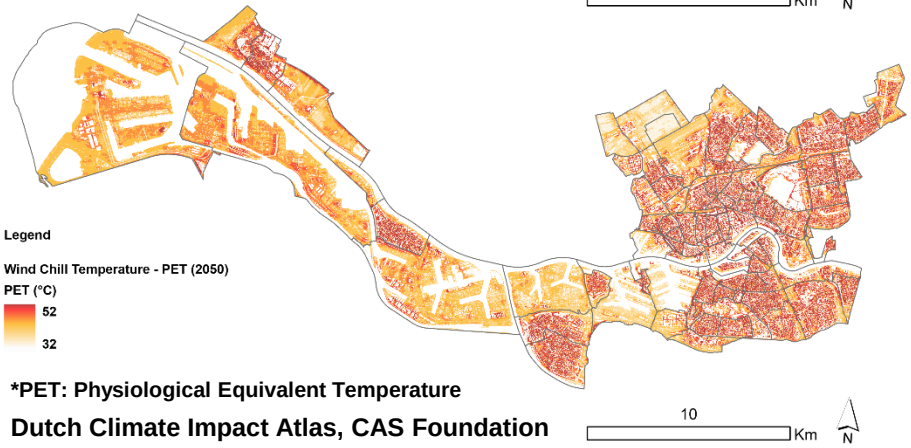
- **BECOME 100% CLIMATE-NEUTRAL THROUGH VISION AND COLLABORATION**

ARCADIS

https://www.landscape-architects.nl/en/projects/duurzaam-schouwburgplein

CITY SCALE: Urban Heat in Rotterdam

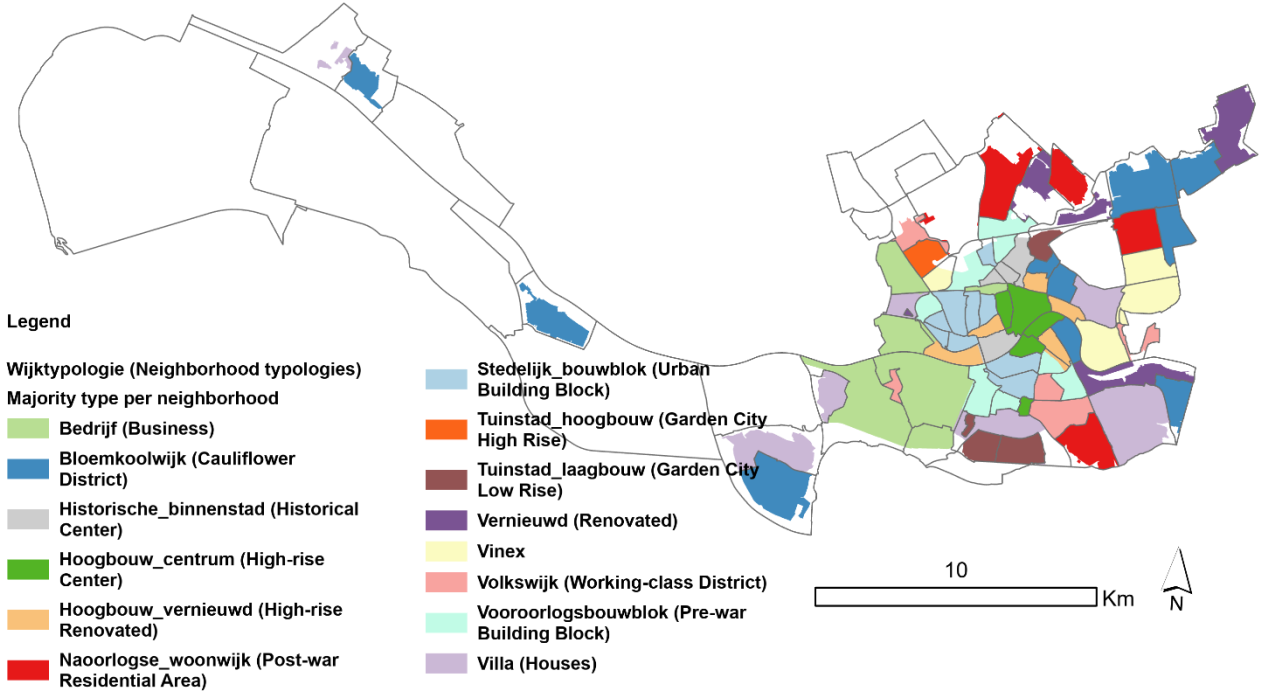




*PET: Physiological Equivalent Temperature

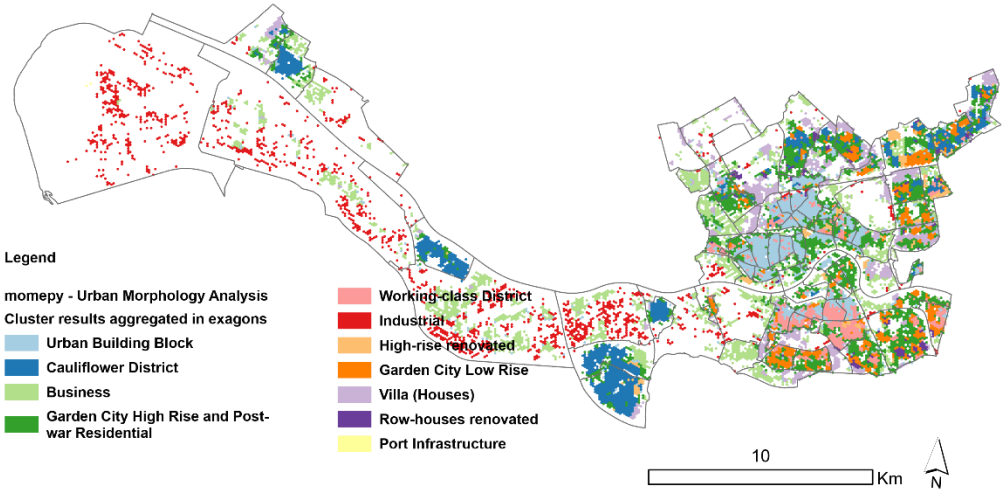
Dutch Climate Impact Atlas, CAS Foundation and Research Institutes https://www.klimaateffectatlas.nl/

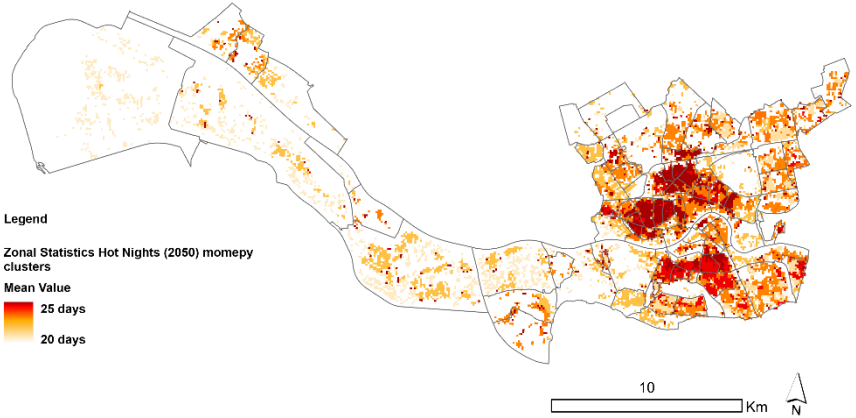
CITY SCALE: HvA/TAUW Neighborhood Typologies

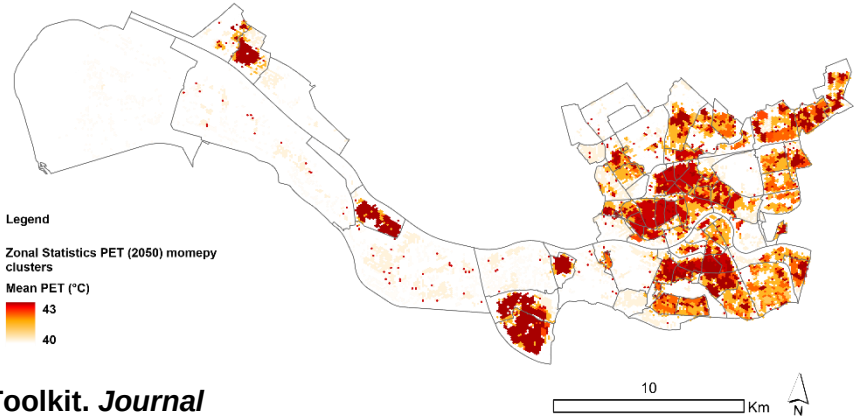


Typical neighborhood layouts for Rotterdam based on the Amsterdam University of Applied Sciences model book on climate-proofing residential streets, which is based on the Kleerekoper classification (2016) Source: Climate Impact Atlas, HvA/TAUW

CITY SCALE: momepy Morphology Classification





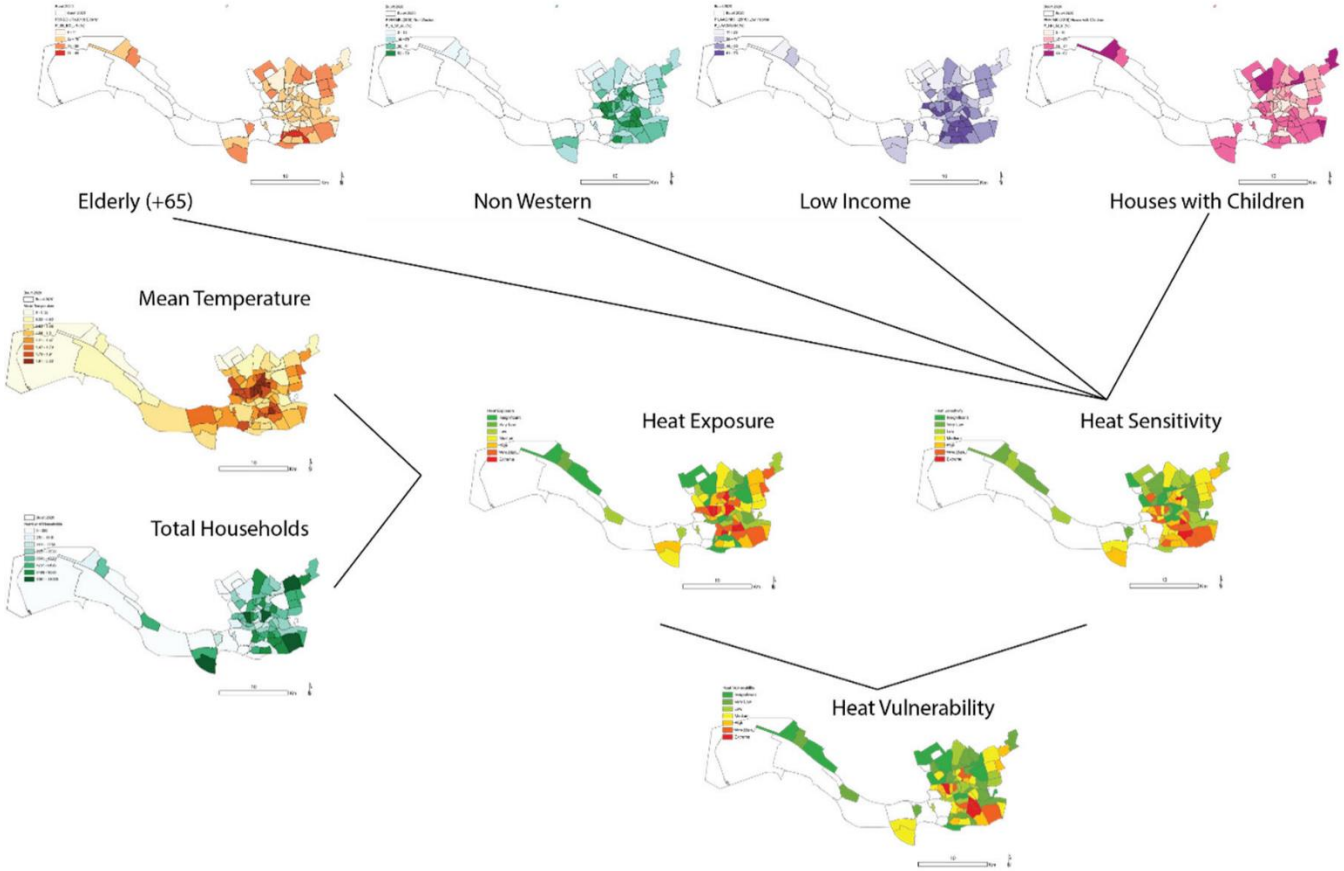


Urban form classification using the momepy script. [4]
Building clusters were converted to 1 ha hexagons.

[4] Fleischmann, M. (2019). momepy: Urban Morphology Measuring Toolkit. *Journal of Open-Source Software* 4 (43), 1807. https://doi.org/10.21105/ joss.01807

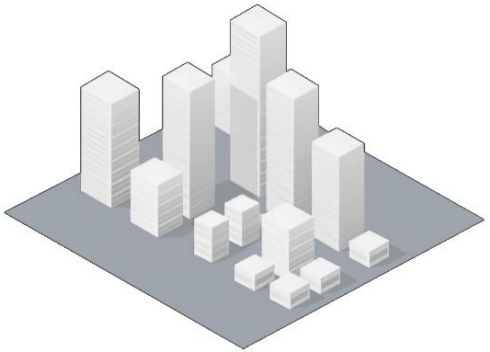
CITY SCALE: Heat Vulnerability

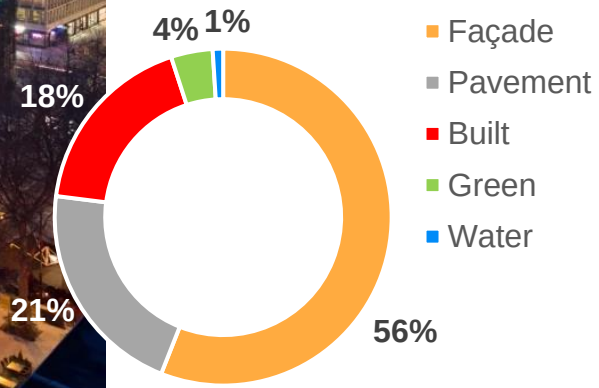
Summary of heat vulnerability process: a simple sum of the class ranks attained from statistical indicators of vulnerable groups. Heat exposure was calculated from the mean temperature obtained from the UHII raster image (VITO UrbClim model) combined with statistical data at the neighborhood level.



LOCAL SCALE: High-Rise City Center

Source: Rotterdam Partners





LOCAL SCALE: Bottom-up Urban Area Development

- 7 Square Endeavour (7SE) is an initiative that aims to prepare cities for the future – leading by example.
- This initiative first originated on Schouwburgplein Rotterdam, as a bottom-up project of Theater Rotterdam and De Doelen concert hall. It has now developed into a public-private collaboration between several organizations in the area, government institutions, and expert knowledge centers.
- This partnership consists of: Amvest, Arcadis, de Doelen, Dura Vermeer, Gemeente Rotterdam, HHSK, Manhave, het Ministerie van I&W, Theater Rotterdam and TNO.

7 Square Endeavor: Water Strategy Guiding Principles

> **Flooding is prevented in the area:** rainwater is diverted and not discharged in the mixed sewer system.

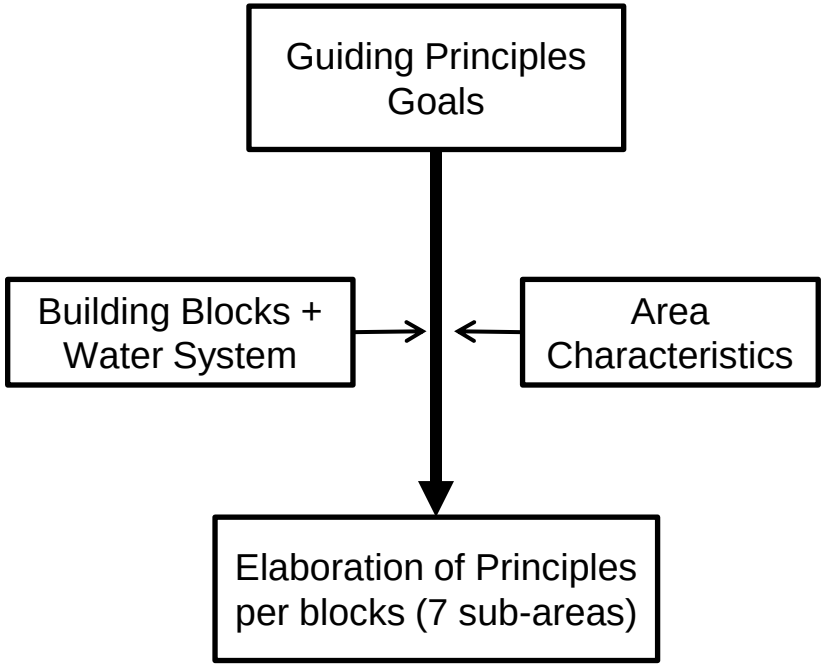
> **Clean water must remain clean:** no mixing of clean and dirty water in mixed systems.

> **Water is an important raw material:** no water is wasted.

> **Clean water in plain sight as much as possible:** for more water experience and water education.

> **Water belongs to all of us:** we bear joint responsibility for it.

> **Apply innovative techniques:** to deal with stormwater and wastewater in a different way.

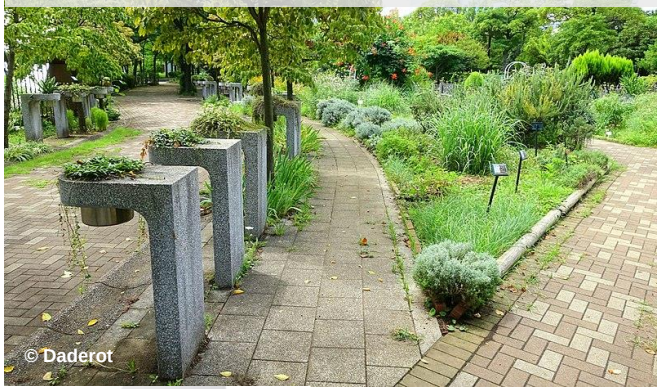


Water Strategy: Measures at the "Blocks' Level"

City Stream

Green Walls

Greening and Softening



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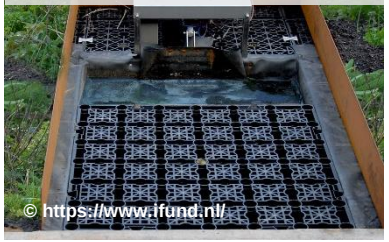
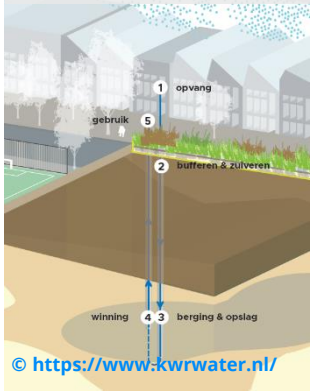


Decentralized Wastewater Treatment

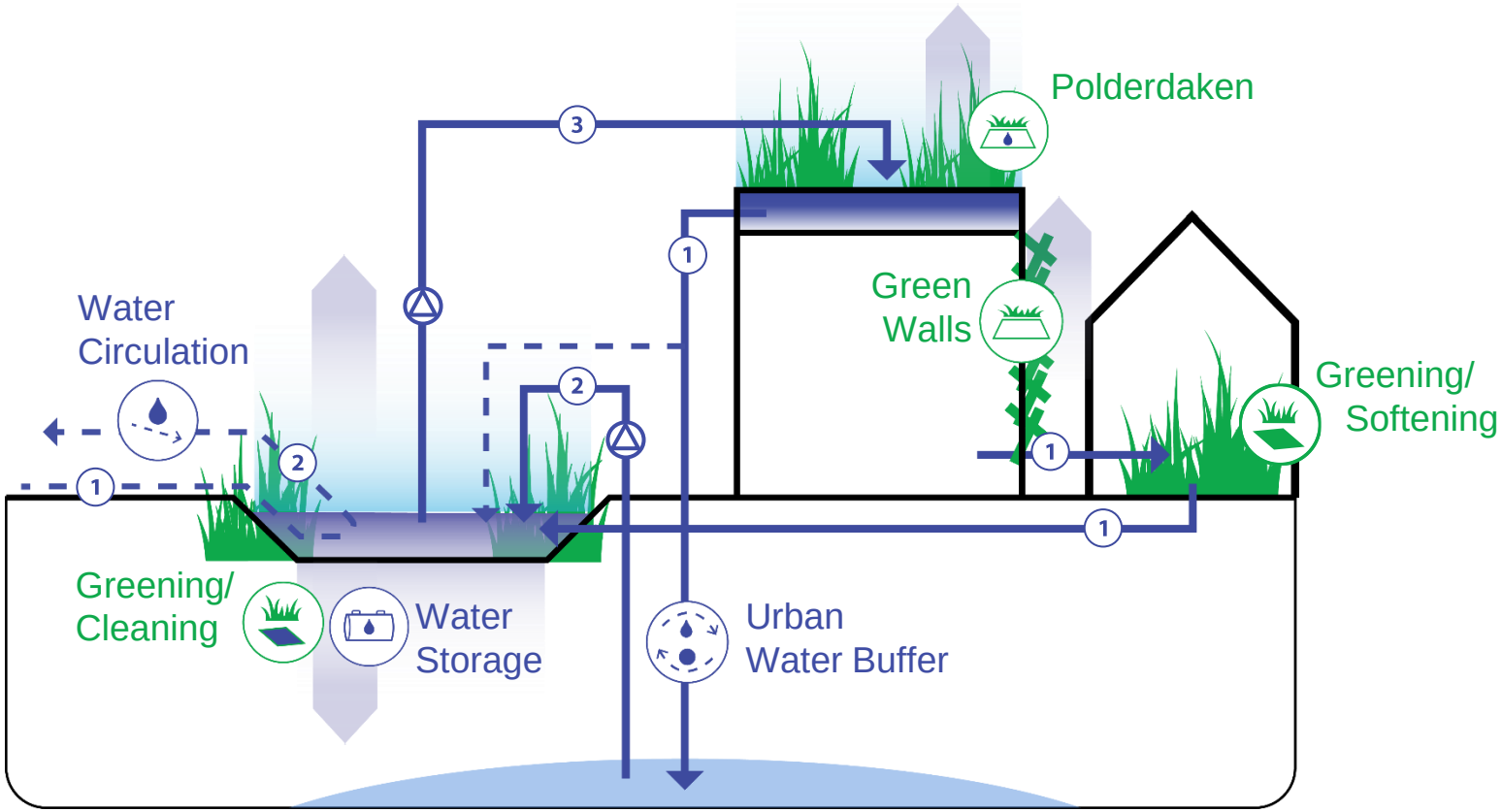
Urban Water Buffer



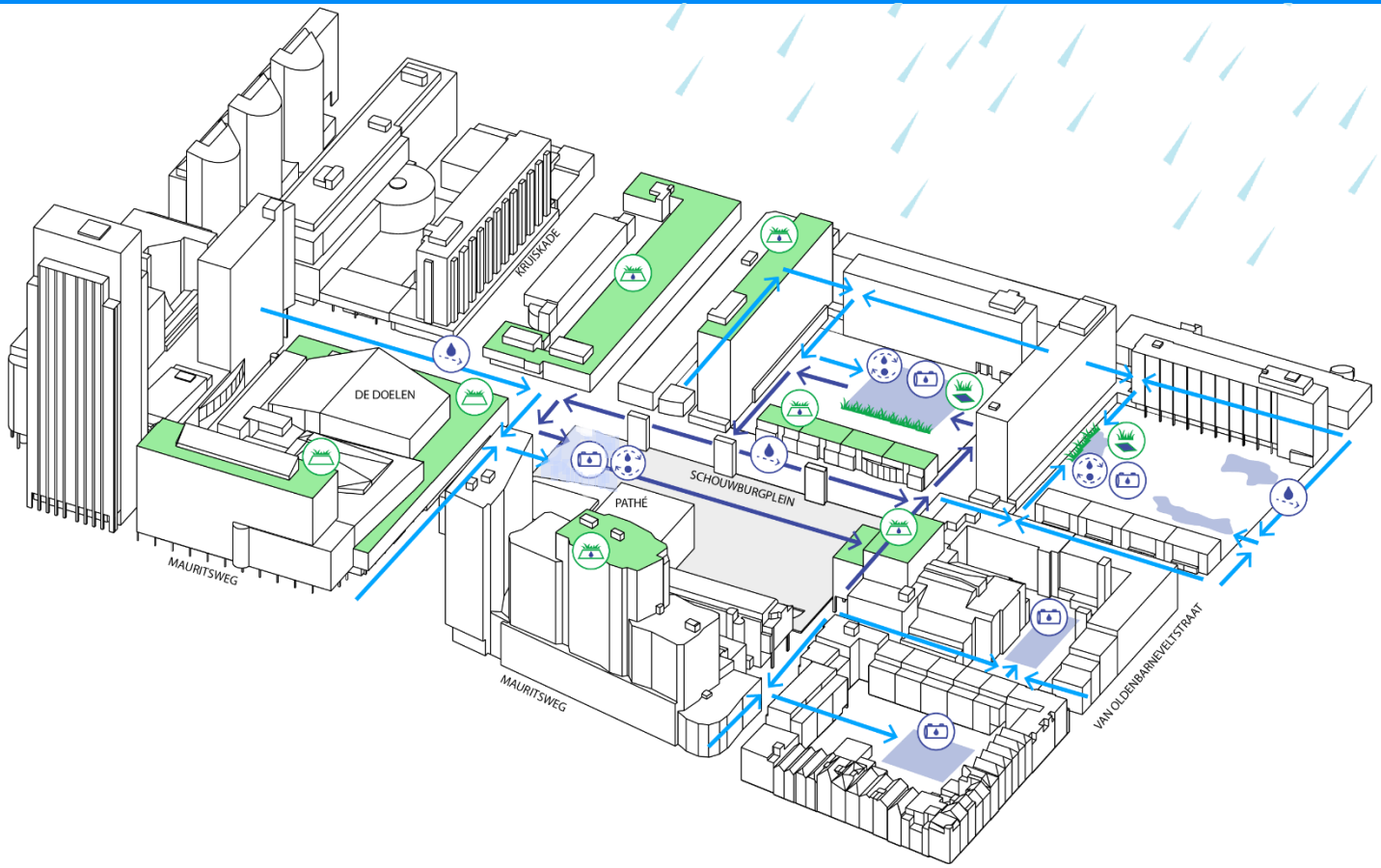
Visible Water

Water Storage

Water Strategy: Water Circulation Strategy

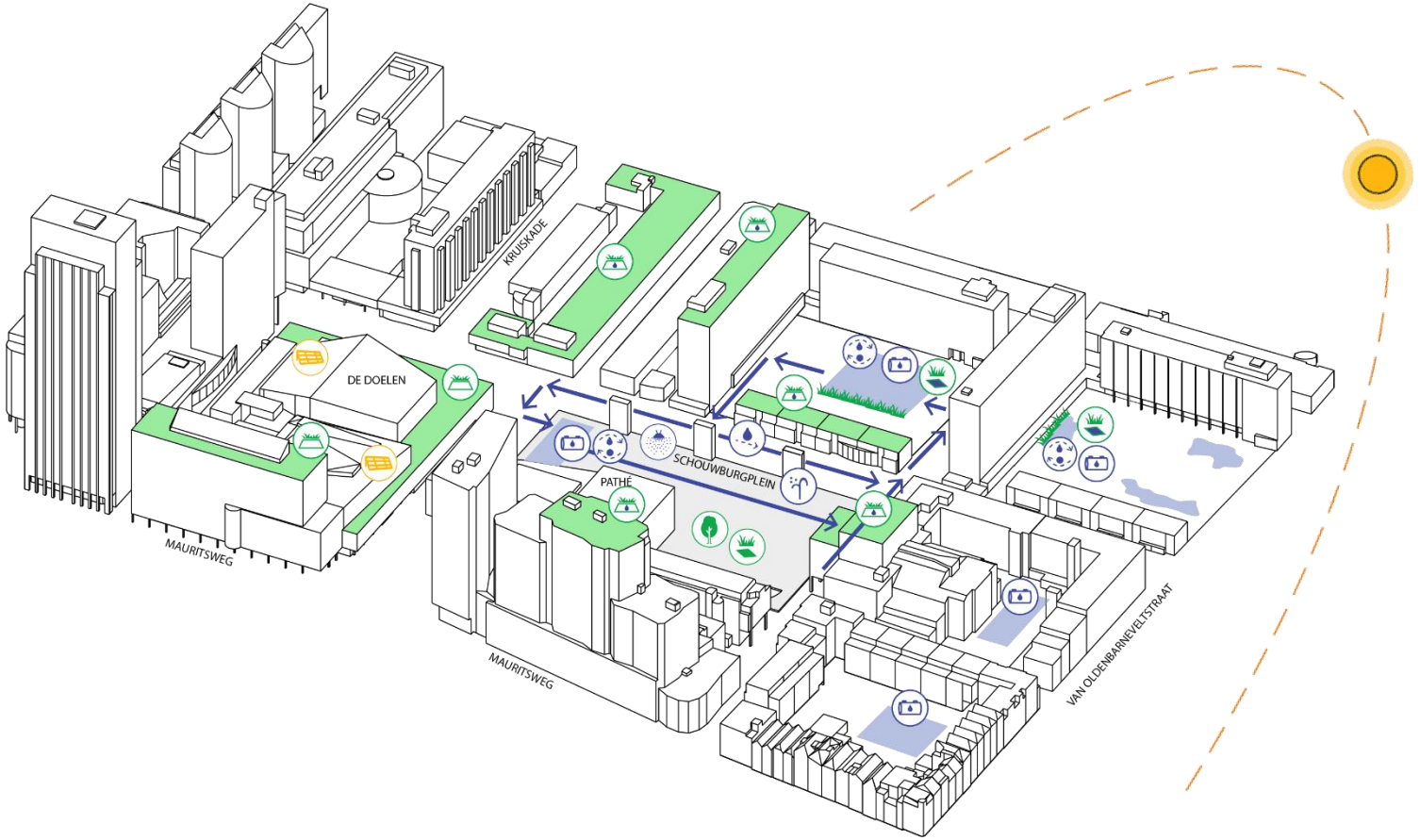


Water Strategy: Stormwater Management During Storms



- Water Circulation
- Urban Water Buffer
- Water Storage
- Water Fountain
- Water Mists
- Green Roofs/ Walls
- Polderdaken
- Greening/ Softening
- Greening/ Cleaning
- Trees

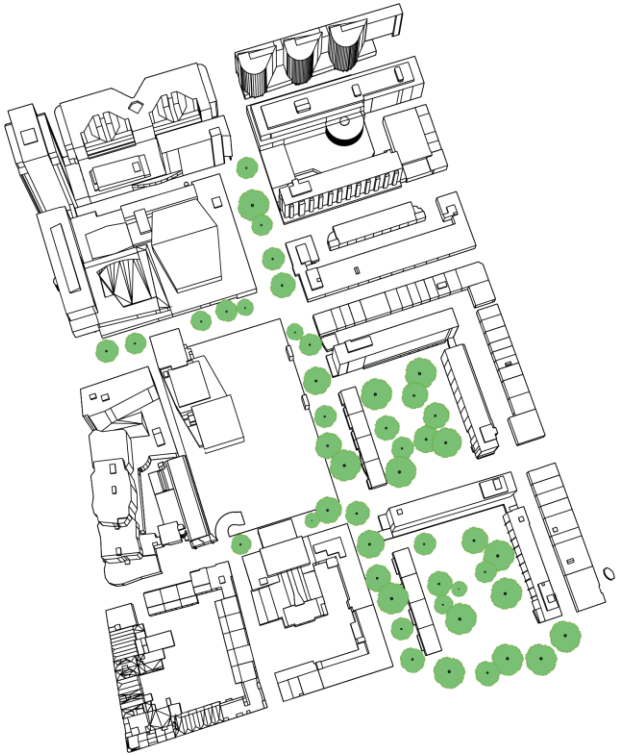
Water Strategy: Water Recirculation and Cooling During Summer



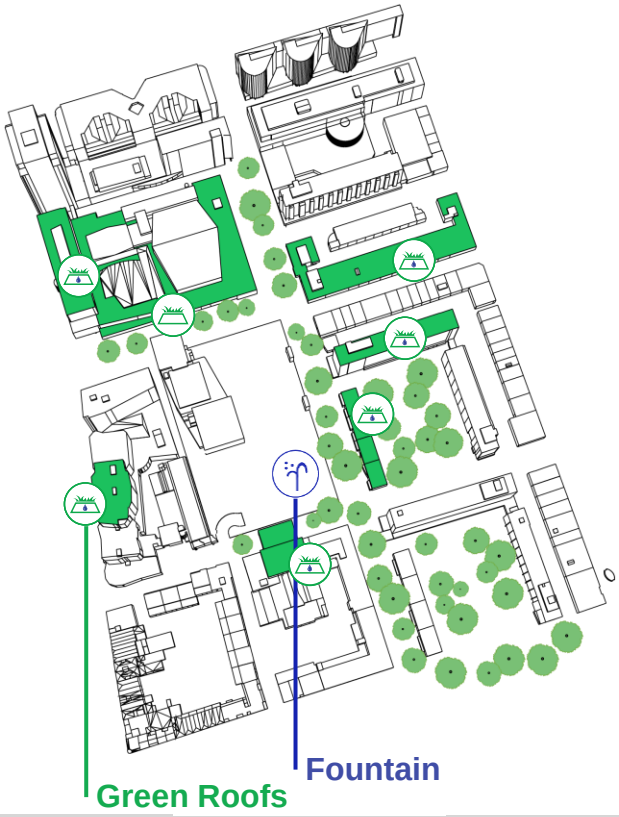
- Water Circulation
- Urban Water Buffer
- Water Storage
- Water Fountain
- Water Mists
- Green Roof/Walls
- Polderdaken
- Greening/ Softening
- Greening/ Cleaning
- Trees

Thermal Comfort: Cooling Schouwburgplein

Baseline – Scenario 0



Scenario 1



Scenario 2

Thermal Comfort: Baseline PET and Mean Radiant Temperature

Baseline PET (Without Measures)
14.00 23.06.18
Max: 30.97 ºC

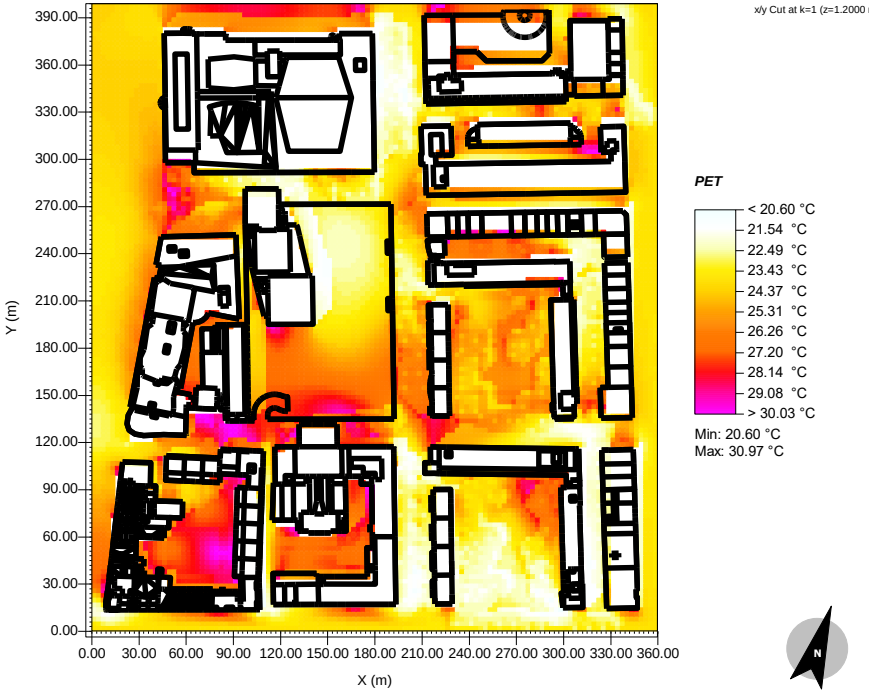
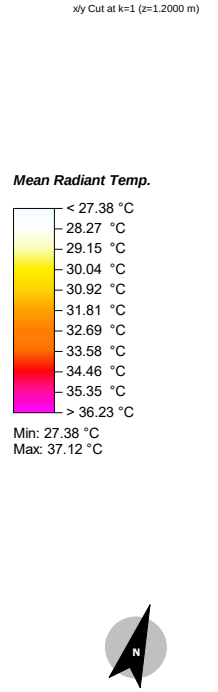


Figure 1: BaselineSquare
14.00.01 23.06.2018

Baseline MRT (Without Measures)
14.00 23.06.18
Max: 37.12 ºC

Figure 2: BaselineSquare
14.00.01 23.06.2018



***PET: Physiological Equivalent Temperature (Thermal Comfort Index)**

Thermal Comfort: Comparison Baseline and Scenarios for PET

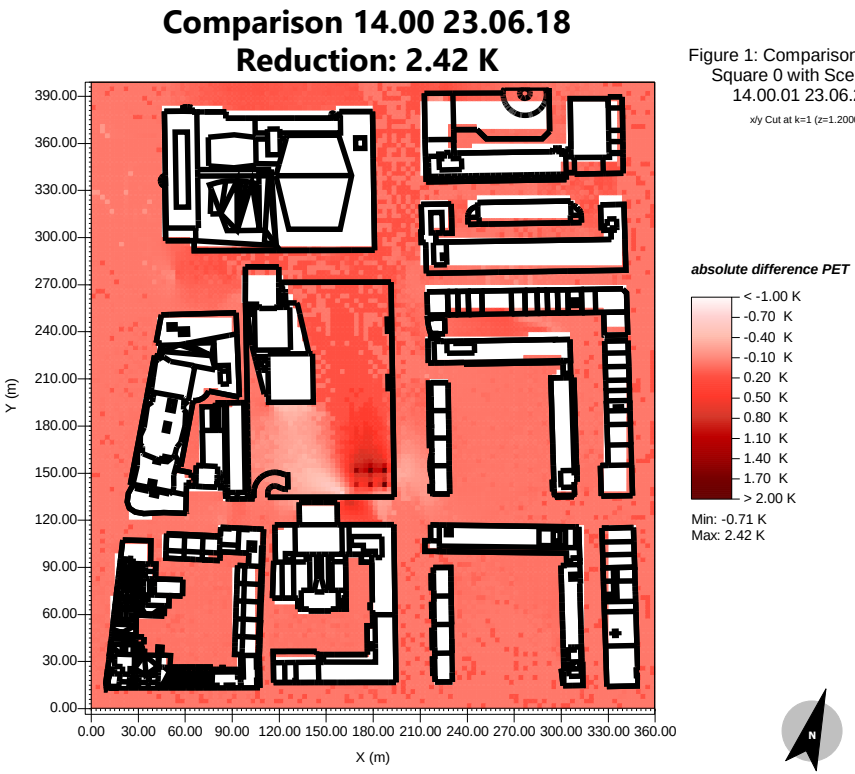


Figure 1: Comparison Baseline Square 0 with Scenario 1
14.00.01 23.06.2018

x/y Cut at k=1 (z=1.2000 m)

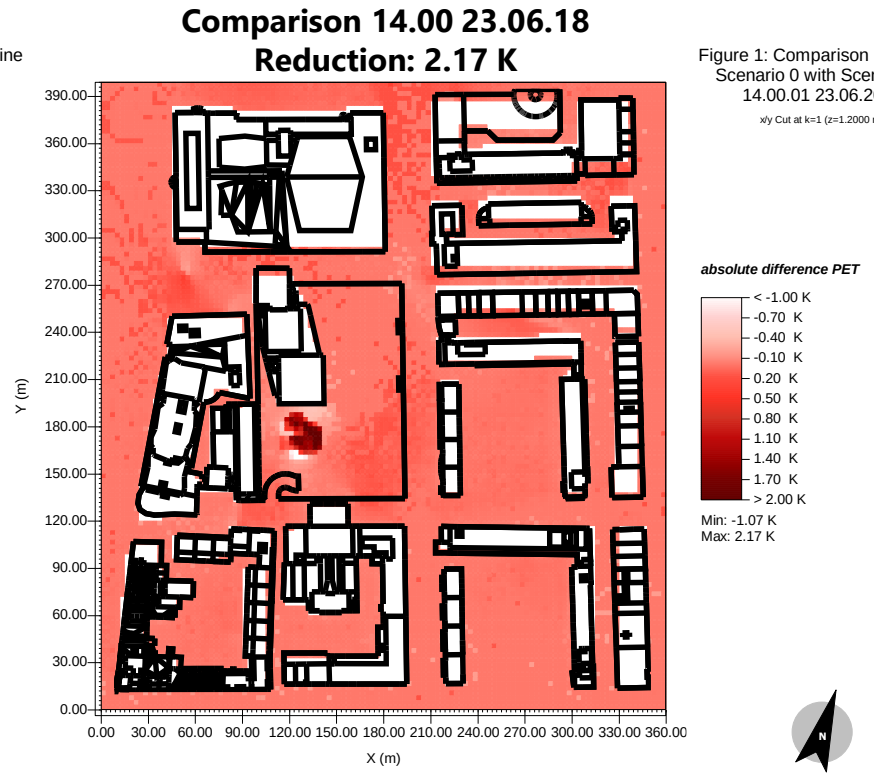


Figure 1: Comparison Baseline Scenario 0 with Scenario 2
14.00.01 23.06.2018

x/y Cut at k=1 (z=1.2000 m)

Thermal Comfort: Results and Validation from Literature

[5] Boukhabla M., Alkama D., (2012) Impact of vegetation on thermal conditions outside, Thermal modeling of urban microclimate, Case study: the street of the republic, Biskra. In: *Energy Procedia*, 18. Elsevier
[6] Davtalab J. et al, (2020) The impact of green space structure on physiological equivalent temperature index in open space. In: *Urban Climate*, 31. Elsevier
[7] Dessì, V. (2008) Use of simplified tools to evaluate thermal comfort in urban spaces in the teaching experience. In: Proceedings of PLEA- Toward zero energy buildings. University College Dublin.
[8] Ulpiani G. et al. (2019) Thermal comfort improvement in urban spaces with water spray systems: Field measurements and survey. In *Building and Environment*, Elsevier, Berkeley, CA. USA.
[9] Ulpiani G. et al. (2019) Water nebulization to counteract urban overheating: development and experimental test of a smart logic to maximize energy efficiency and outdoor environmental quality. In: *Applied Energy,* Berkeley, CA. USA.
[10] Nishimura N. et al. (1998) Novel water facilities for the creation of comfortable urban micrometeorology. In: *Solar Energy,* 64. Elsevier. Berkeley, CA. USA.
[11] Xue F. et al. (2014) Modeling the influence of fountain on urban microclimate. In: *Building Simulation*, Springer.

- The presence of trees could be responsible for a reduction of air temperature and solar radiation due to shading of about **0.5-2°C** and an increase of relative humidity of about **1-3%** [5] [6] [7]
- Considering the water-based cooling (fountains and nebulizers), air temperature and relative humidity would change, and probably also solar radiation being partly reflected by the water droplets: air temperature can decrease of **3-10°C** as the relative humidity can increase up to **20-30%** [8] [9] [10] [11].
- It is well known that the most important effect on thermal comfort happens due to Solar Radiation decrease in the central and hottest hours of the day—with an important decrease also in terms of Mean Radiant Temperature (that affects PET).
- Green roofs are only effective at the pedestrian level when applied extensively in the whole city, thus affecting the UHI in the City Scale.

Conclusions

- **Water is a key guiding element:** if well managed and reused can increase open space liveability and inclusiveness;
- We need to involve both the **public and private agents** in addressing excess stormwater and urban heat, thus the 7 Square Endeavor is an example for other cities;
- **Green roofs** have multiple benefits (including water storage), but help in addressing UHI in the City Scale and not in the Blocks Scale.
- In summary, a well-balanced design proposal for contemporary public spaces has to address **water, energy, liveability,** and **thermal comfort**, which will in turn increase space usability;

Final Considerations

This presentation is part of the research conducted by the first author included in the SOLOCLIM Programme (Solutions for Outdoor Climate Adaptation), a European Industrial Doctorate project funded by the European Commission within the MSCA- Horizon 2020 program (Horizon 2020 Grant No. 861119).

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THANK YOU!