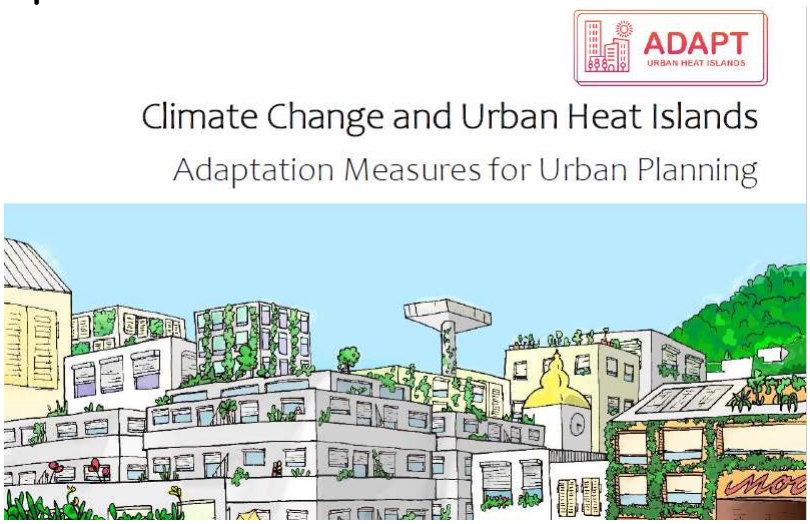
URBAN CLIMATOLOGY

X. Adaptation and mitigation

Paper to read



https://is.muni.cz/auth/el/sci/podzim2022/ZX601/um/67875456/10_ADAPT_UHI_Brochure_EvaluationMeasures.pdf

Summary of expected climate changes in Central Europe

- Rising temperatures and higher intensity of Urban Heat Island
- Higher frequency and longer duration of heat waves
- Changes in precipitation distribution during a year
- More frequent occurrence of high precipitation totals of short duration, higher probability of local floods
- Higher frequency of drought periods without precipitation

Negative effects prevail
Heat load is increasing

Survive New York's Heat Waves
Stay cool during your trip to New York
(http://www.frenzytours.com)

Adaptation and mitigation in urban climatology

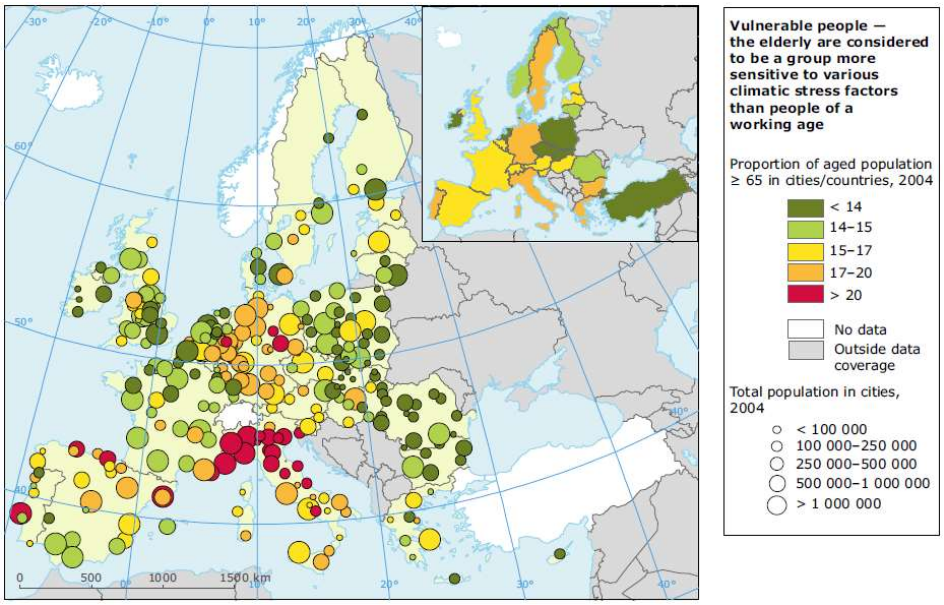
- Besides „physical controls" urban climatology has also „human / social controls"

https://jpi-urbaneurope.eu

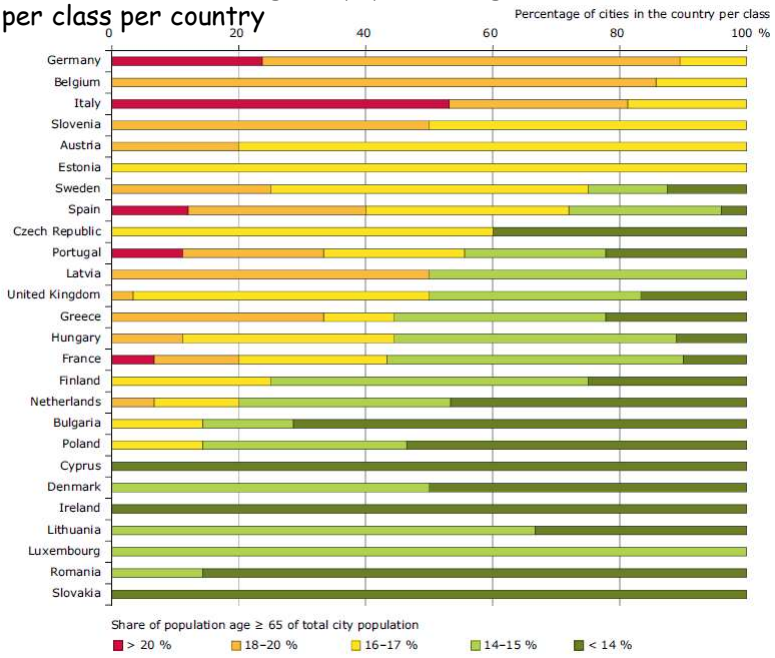
- In cities climate change is **strongly intertwined** with other **socio-economic changes**: demographic trends, higher proportion of older people, urbanization, competing demand for water, etc.
- These socio-economic changes **increase the vulnerability** of people, property and ecosystems under current climate conditions as long as no adaptation measures are taken.
- Negative impacts of climate change in cities require various **actions**, strategies, technologies that help inhabitants **to adapt or mitigate**.

Human controls — the elderly are considered to be a group more sensitive to various climatic stress factors than people of a working age

(Urban adaptation to climate change in Europe, EEA Report 2012)

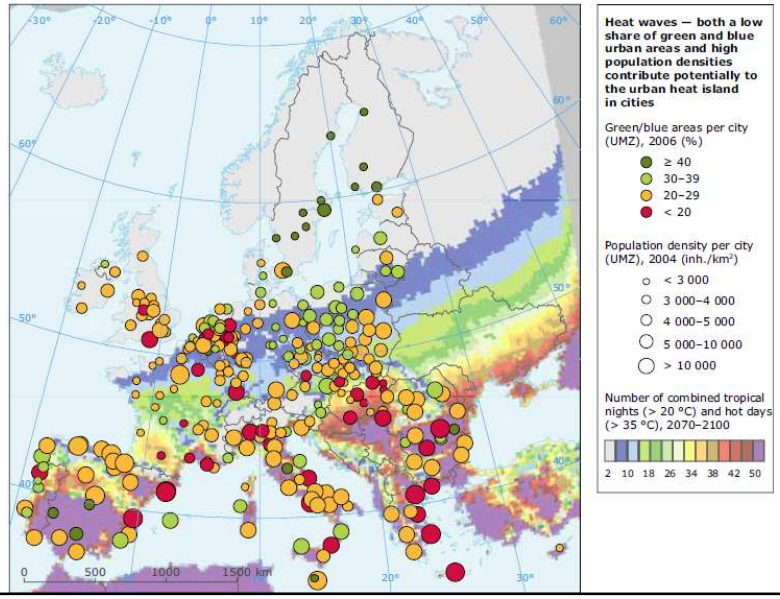


Human controls - Percentage of population aged ≥ 65 — share of cities per class per country

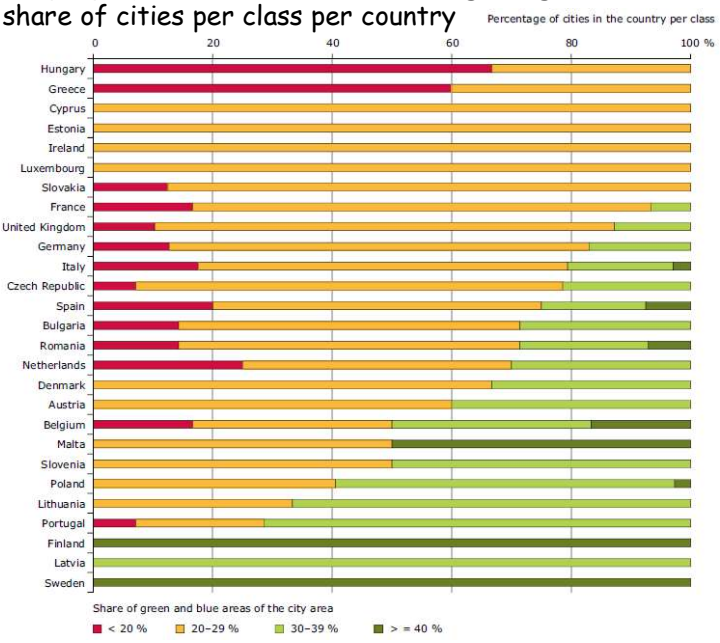


(Urban adaptation to climate change in Europe, EEA Report 2012)

Human and geographical controls - Low share of green and blue urban areas and high population densities can contribute to the urban heat island effect in cities *(Urban adaptation to climate change in Europe, EEA Report 2012)*



Human and geographical controls - Percentage of green and blue urban areas — share of cities per class per country



(Urban adaptation to climate change in Europe, EEA Report 2012)

Adaptation and mitigation - terminology

Adaptation to climate change is the adjustment in urban areas in response to actual or expected effects of adverse climate. It moderates harm or exploits beneficial opportunities of climate change.

Mitigation of climate change is an anthropogenic intervention to reduce the anthropogenic forcing of the climate system. It includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.

Resilience is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization and the capacity to adapt to stress and change.

Adaptation strategies (approaches)

1. **'Grey' infrastructure approaches** - physical interventions or construction measures and using engineering services to make buildings and infrastructure essential for the social and economic well-being of society more capable of withstanding extreme events.
2. **'Green' infrastructure approaches -** contribute to the increase of ecosystems resilience and can halt biodiversity loss, degradation of ecosystem and restore water cycles. At the same time, green infrastructure uses the functions and services provided by the ecosystems to achieve a more cost effective and sometimes more feasible adaptation solution than grey infrastructure.
3. **'Soft' approaches** - include policies, plans, programs, procedures, information dissemination and economic incentives to reduce vulnerability, encourage adaptive behavior. They are related to behavioral changes, emergency systems and the adequate provision of information to vulnerable groups.

Adaptation approaches and measures

Overview on grey, green and soft adaptation measures to heatwaves
(Urban adaptation to climate change in Europe, EEA Report 2012)

Grey measures	Green measures	Soft measures
• Building insulation to keep the inside cool • Blinds to provide shade • Passive cooling of buildings • Urban designs providing shade • Ventilation of urban space by intelligent urban design • Emission reduction of air pollutants	• Boosting green infrastructure, such as green urban areas, trees, green walls and roofs where possible, but ensuring sustainable watering • Ensuring that fresh air from green areas outside the city can flow in	• General awareness raising and ensuring broad participation • Mapping of urban heat island as well as cool places • Identification of vulnerable groups and their distribution as basis for targeted action • Warning systems • Heat action plans including appropriate institutional structures • Preparedness of health and social care system • Information on adapting behaviour during heatwaves in particular to the vulnerable • Adapting building codes to include insulation and shadowing to cope with heatwaves • Consider reducing heatwave impacts through urban renewal projects and urban planning • Transport management to reduce air pollutants

Adaptation strategies (approaches)

Resilient cities


"green" city


"blue" city


"white" city

Further possibilities:

- Energy saving and passive houses
- Warning systems and disaster risk management programs
- Urban adaptation relies on action beyond cities' borders (flooding due to inappropriate land use and flood management in upstream regions) and incudes reducing cities' dependency on external services

Causes of urban warming and mitigation strategies (Grimmond, 2007)

Urban heat island causes	Mitigation strategy
Increased surface area	
Large vertical faces	
Reduced sky view factor	
Increased absorption of shortwave (solar) radiation	High reflection building and road materials, high reflection paints for vehicles
Decreased longwave (terrestrial) radiation loss	Spacing of buildings
Decreased total turbulent heat transport	Variability of building heights
Reduced wind speeds	
Surface materials	
Thermal characteristics	
Higher heat capacities	Reduce surface temperatures (changing albedo and emissivity)
Higher conductivities	Improved roof insulation
Increased surface heat storage	
Moisture characteristics	
Urban areas have larger areas that are impervious	Porous pavement
Shed water more rapidly – changes the hydrograph	Neighbourhood detention ponds and wetlands which collect stormwater
Increased runoff with a more rapid peak	Increase greenspace fraction
Decreased evapotranspiration (latent heat flux, Q_E)	Greenroofs, greenwalls
Additional supply of energy – anthropogenic heat flux – Q_F	
Electricity and combustion of fossil fuels: heating and cooling systems, machinery, vehicles.	Reduced solar loading internally, reduce need for active cooling (shades on windows, change materials)
3-D geometry of buildings – canyon geometry	District heating and cooling systems
	Combined heat and power systems
	High reflection paint on vehicles to reduce temperature
Air pollution	
Human activities lead to ejection of pollutants and dust into the atmosphere	District heating and cooling systems
Increased longwave radiation from the sky	Combined heat and power or cogeneration systems
Greater absorption and re-emission ('greenhouse effect')	

Examples of adaptation measures

Shading effect, evaporation of water into the atmosphere and its storage in soil

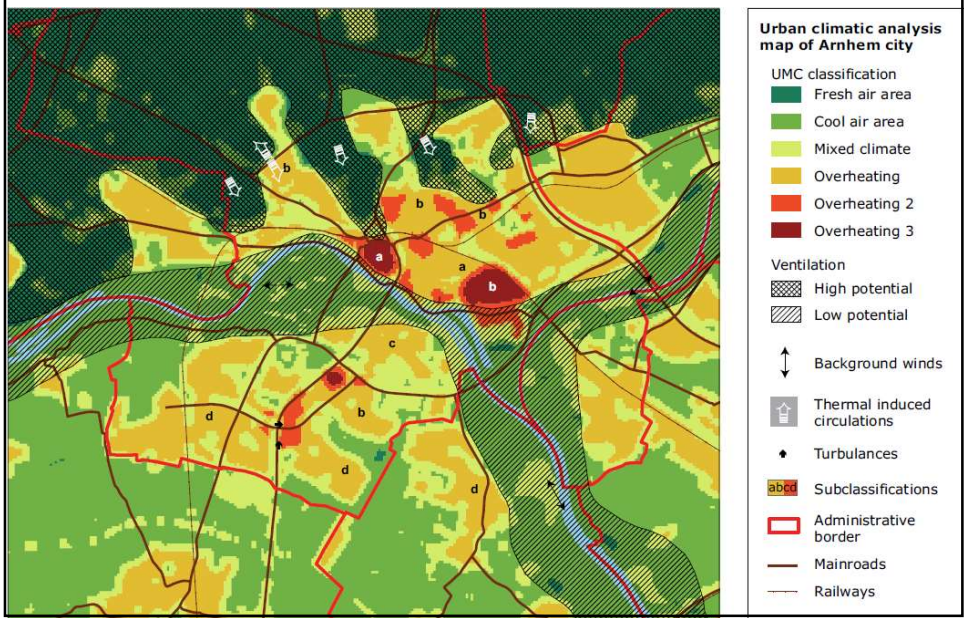
Green tram tracks (Mulhouse, France)

Grey measure - shading of a public square in Benicassim, Spain (© urbadis)

Soft measure – change in our mind
(© projectADAPT-UHI(KR17AC0K13693)

Urban climate analysis map for the city of Arnhem, the Netherlands

(Urban adaptation to climate change in Europe, EEA Report 2012)

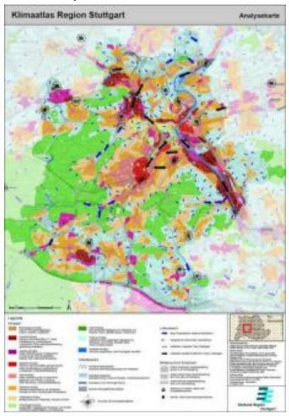


Climate planning strategy, Stuttgart (Germany)

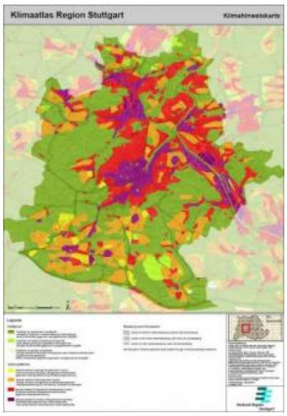
(Urban adaptation to climate change in Europe, EEA Report 2012)

An excellent example of urban heat island management. The city of Stuttgart has been designed to not only respect and protect nature, but to exploit how natural **wind patterns** and **dense vegetation** can actively help the city to reduce its problems of overheating and air pollution.

At night cool air sweeps down from the surrounding hills and runs through a series of 'ventilation-corridors' which have been kept open as wide, tree-flanked arteries within the city's street infrastructure.



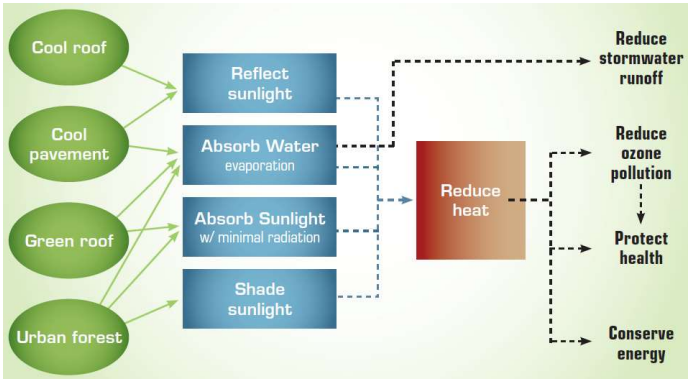
Klimaanalysekarte Stuttgart



Planungshinweiskarte Stuttgart

http://www.stadtklima-stuttgart.de

Benefits of the complex approaches



Source: Harrison Institute for Public Law, 2012.

"Climate sensitive design"

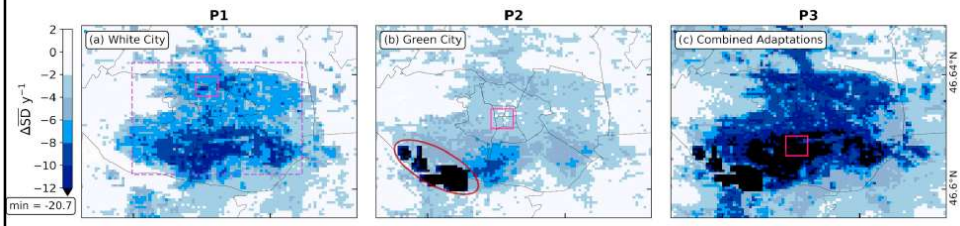
Effectiveness of adaptation strategies

Oswald et al. 2020 – Klagenfurt (Austria)

Two adaptation strategies:

(i) **White** city - an increase in the albedo values of sealed areas (i.e., roofs, walls and streets)

(ii) **Green** city - an increase in green surfaces (i.e., lawns on streets and at roof level) and high vegetated areas (i.e., trees).

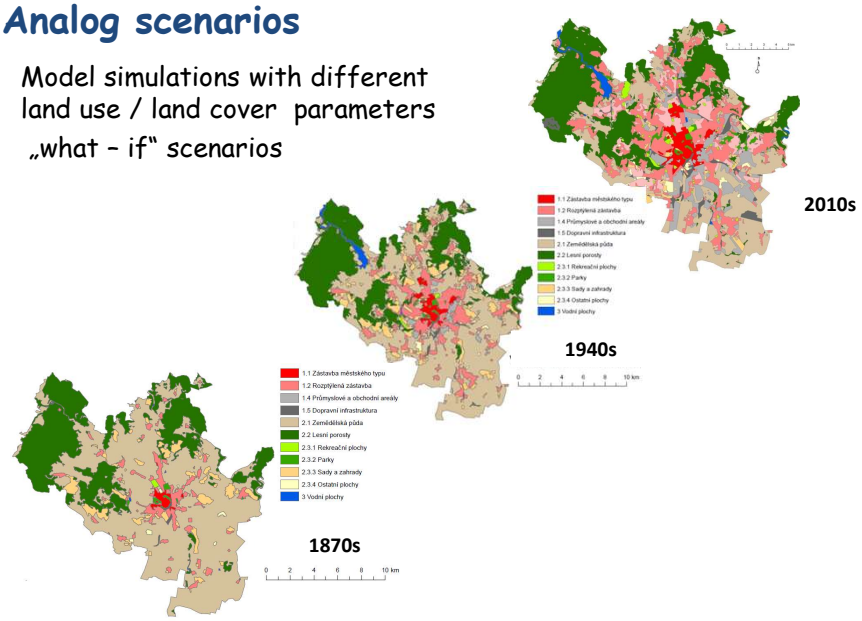


Evaluation of the different climate adaptation measures for the urban area of Klagenfurt. difference in the average number of summer days per year (SD y 1) compared to the reference simulation for the time period 1981–2010.

- Some climate adaptation measures show higher potential in mitigating hot days than others, varying between reductions of 2.3 to 11.0%.
- An overall combination of adaptation measures leads to a maximum reduction of up to 44.0%

Analog scenarios

- Model simulations with different land use / land cover parameters
- „what – if" scenarios



Land cover maps of Brno in 1870s, 1940s and at present

Final remarks and questions

Mills (2006) - the sustainable city is the new urban *utopia*

1. How to persuade politicians (local authorities) that some adaptations/mitigations are needed?
2. What is the role of geographers in the adaptation process of cities to climate change?