Bavarian Environment Agency

Climate Change Impacts and Adaptation Strategies in Bavarian Cities

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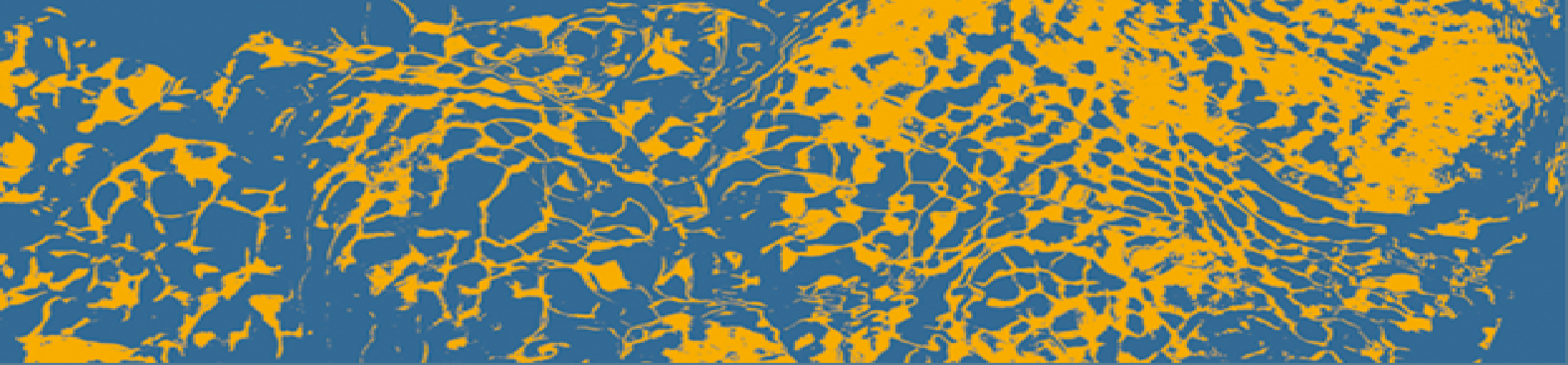
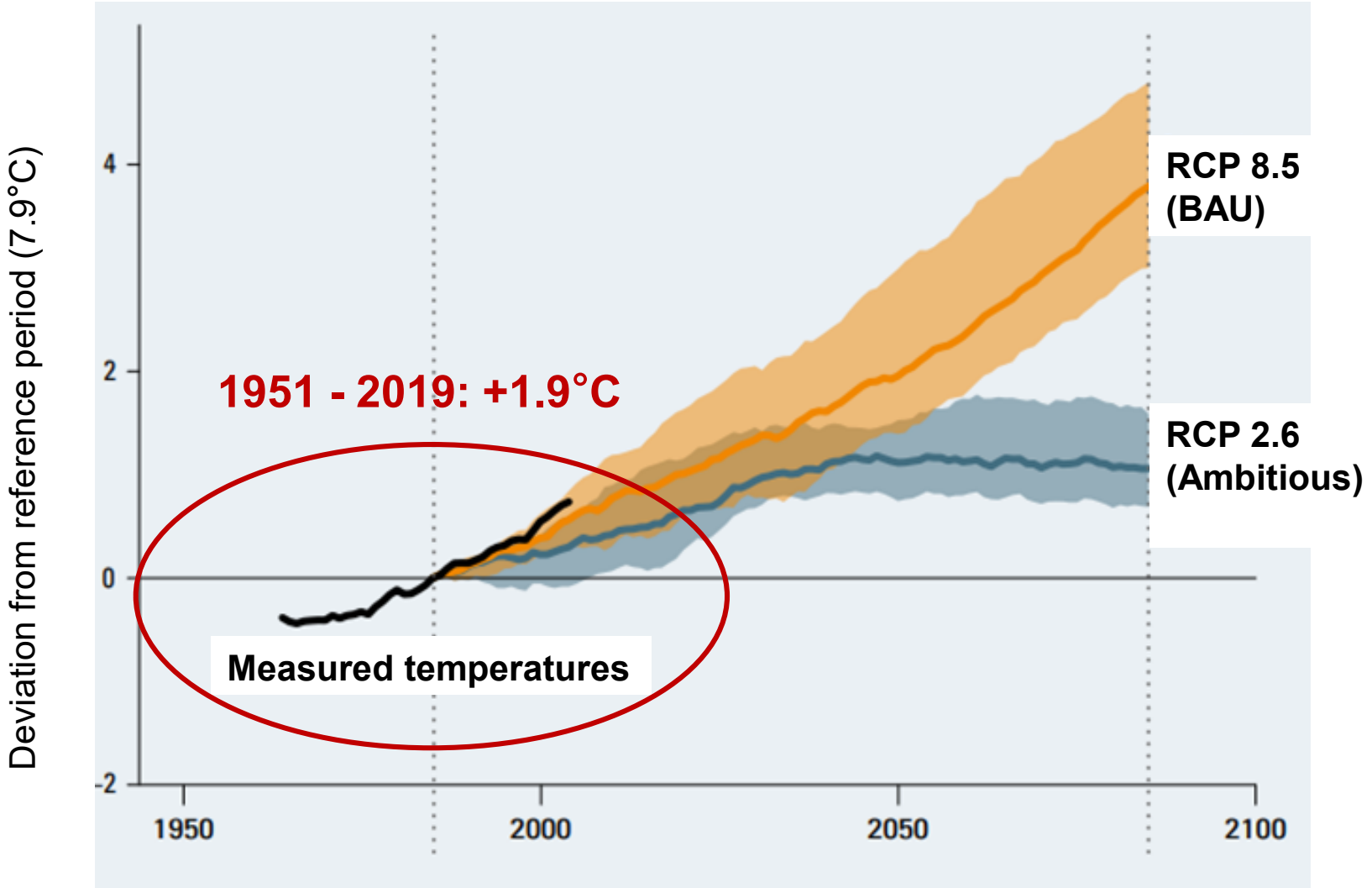


Climate change in Bavaria

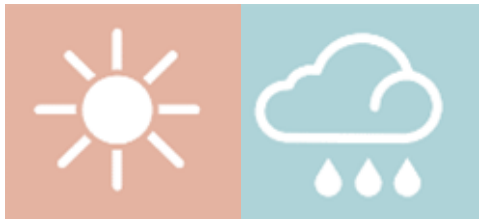
Average annual temperature



By 2100: up + 4.8°C

Climate change in Bavaria

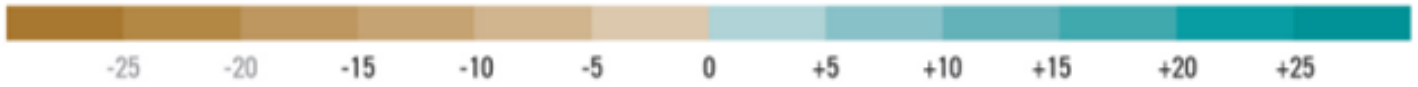
Precipitation



1951 to 2019:
-13% summer rainfall

Drier summers

Wetter winters



Changes in % rainfall reference period (1971-2000) and end of the century

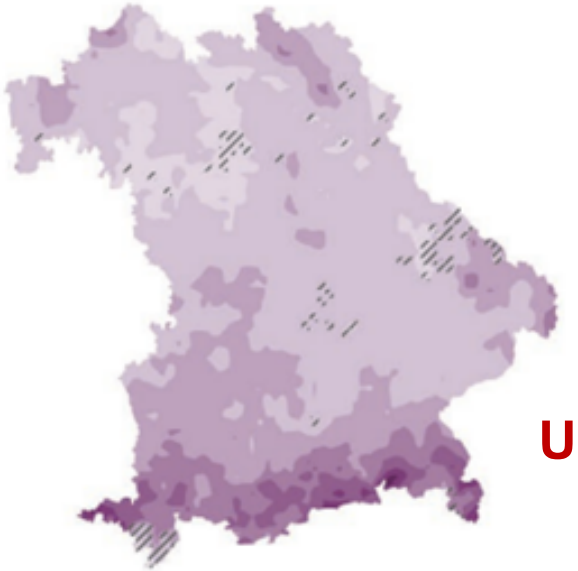
Climate change in Bavaria

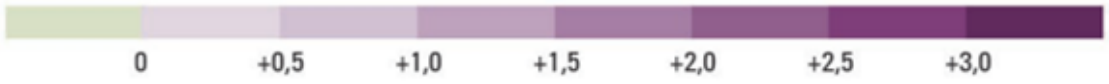
Heavy rain days/year (>30 mm/day)

Average: 4 days

Reference period (1971-2000)

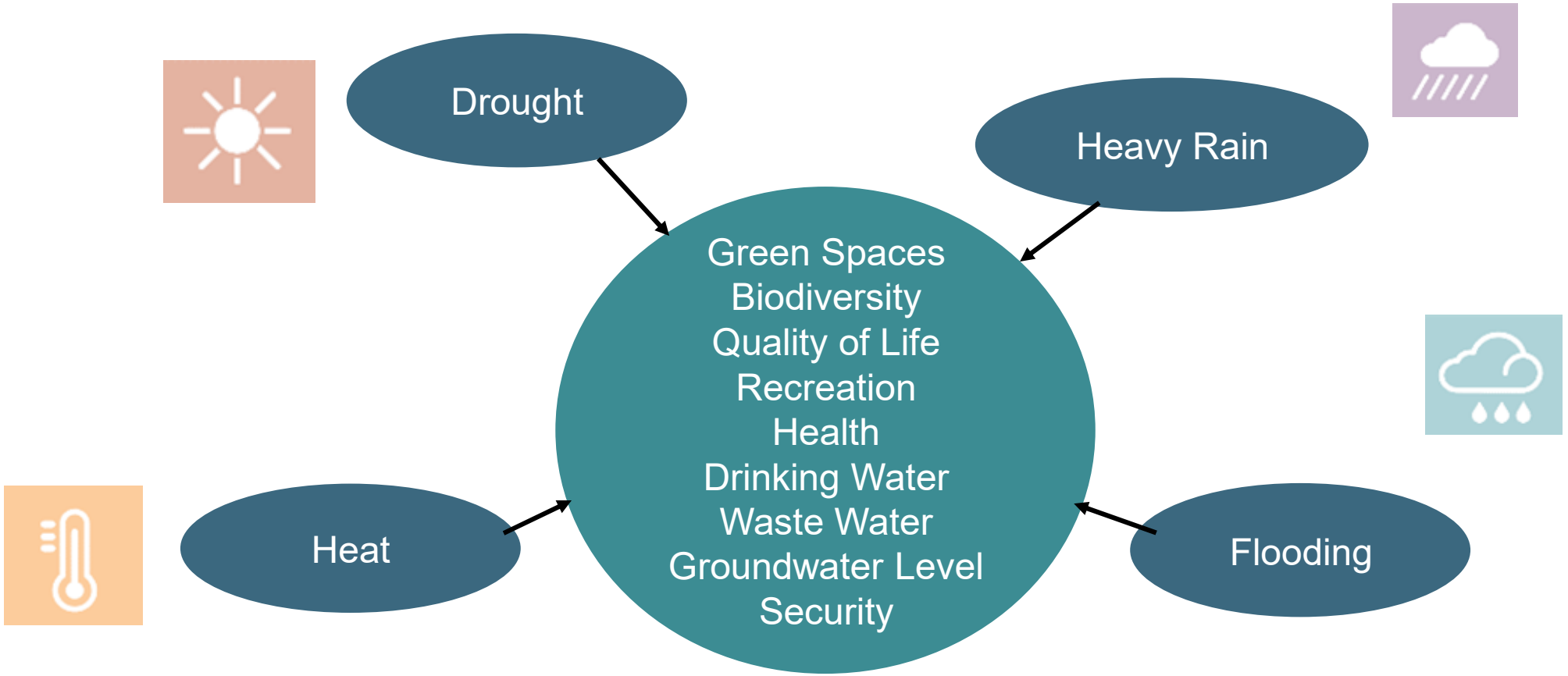
Up to 4 days





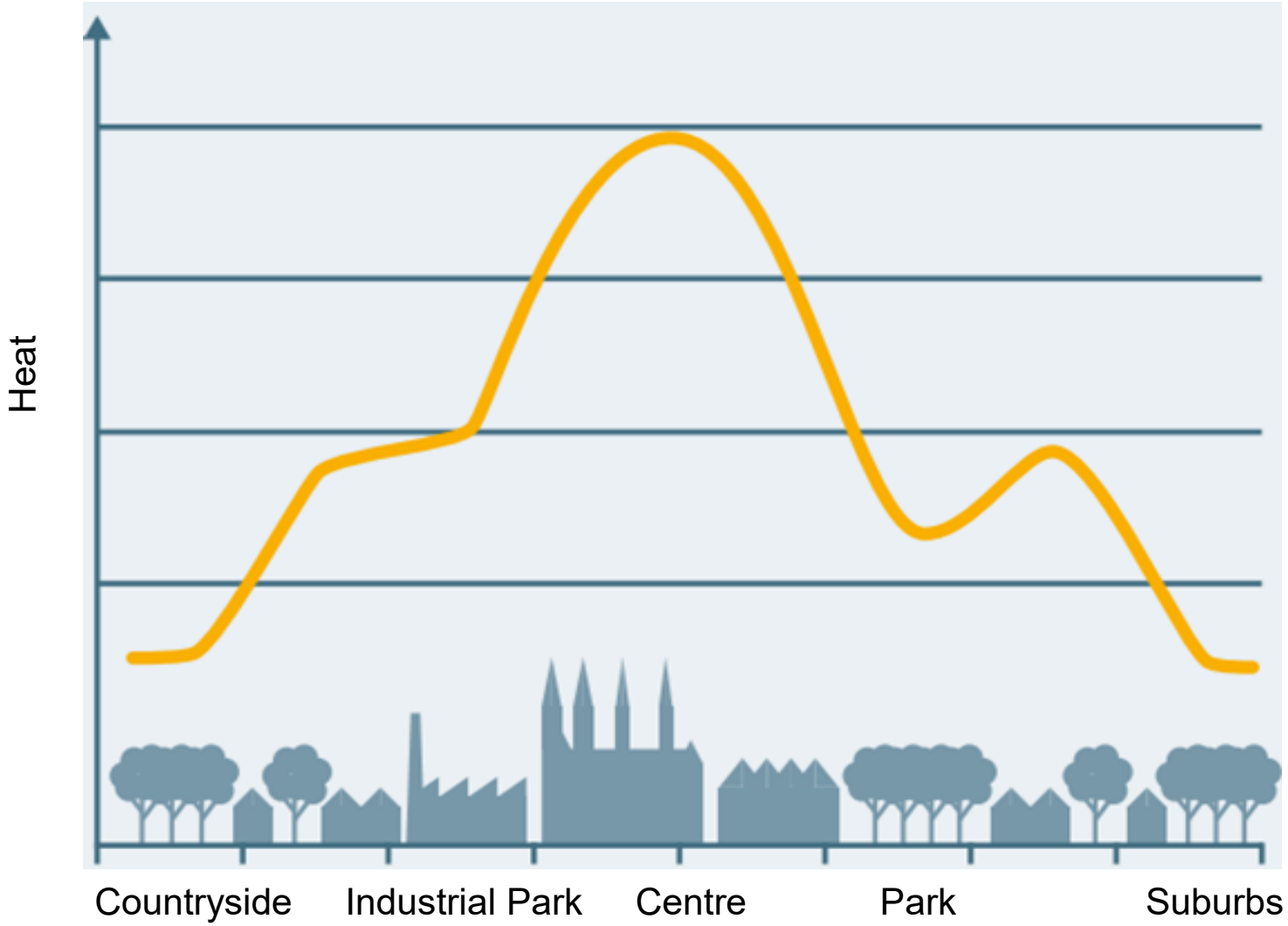
Heavy rain days by end of the century

How will climate change impact urban areas?



Exacerbated through soil sealing and densification !

Urban Heat Island Effect

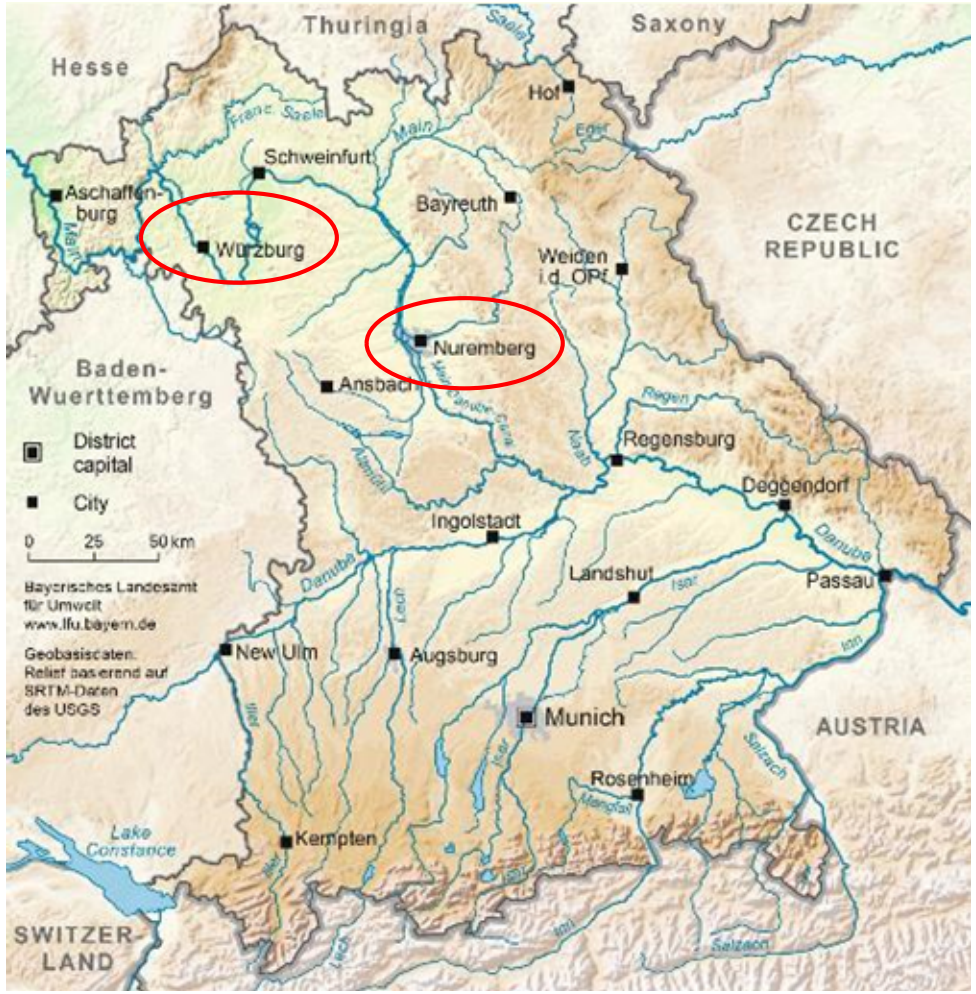


Munich:
ca. 10°C difference on a hot day!

How will climate change impact urban areas?

	Nuremburg (Pop: 515 543)	**Wurzburg (Pop.: 126 954)**
Hot days (>30°C):	12/year to **45/year by 2100**	11/year to **> 50/year by 2100**
Tropical nights (min. 20°C):	>1/year to **33/year by 2100**	will **increase**
Precipitation	**Less rain by 2100**	**Less rain by 2100** (more in winter, less in summer)

=> Conclusion: Drier and Hotter!



Adaptation through Green-Blue Infrastructure

Measures:

1) Permeable surfaces
2) Retention beds
3) Tree with underground water tank
4) Water storage tank
5) Multifunctional spaces
6) Stormwater drainage
7) Retention ditch
8) Nesting places
9) Green Courtyards
10) Green Facades
11) Green Roofs
12) Wetlands
13) Green Corridors
14) Cold-Air Corridors
15) Cold-Air Production Areas

Examples from Bavaria – Water-Permeable Surfaces (1)

Description:

- Remove sealed surfaces or create water-permeable surfaces, e.g. parking spaces, driveways or playgrounds
- Combine permeable layer with grass, where possible

Climatic Effect:

- Improves groundwater regeneration
- Improves microclimate (evaporation)
- Improves biodiversity

Water-permeable parking spaces
© Wolfgang Färber

Grass pavers used for parking spaces or driveways
© Stefanie Schuster

Examples from Bavaria – Water-Retention (2,7)

Description:

- Permeable Flower Beds
- Permeable Ditches
- Placed alongside roads or in grass strips
- Water tanks underground, where possible

Permeable retention ditches at Ackermannbogen, Munich
© Alicia Bilang, München

Climatic Effect:

- Water retention (flood protection)
- Improves microclimate
- Improves groundwater regeneration
- Improves biodiversity

Permeable retention (flower) beds in Haibach
© Gemeinde Haibach

Examples from Bavaria – Water-Retention (3,4)

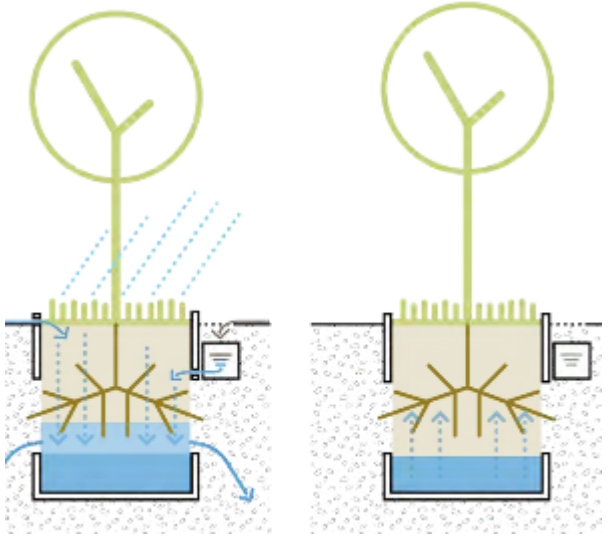
Description:

- Underground water tanks store precipitation and delay infiltration
- Water may be used for plants, where possible
- NEW: Storage tank placed underneath trees (water quality must be assured)

Underground water tank © Hardy Loy

Climatic Effect:

- Water retention (flood protection)
- Improves groundwater regeneration
- Improves microclimate



Tree with underground water storage © MUST Städtebau

Examples from Bavaria – Multifunctional Green Areas (5)

Description:

- water retention area used mainly for recreation in dry periods
- Green, permeable surface (where possible) with biodiversity-rich vegetation and trees

Climatic Effect:

- Improves groundwater regeneration
- Improves biodiversity
- Trees provide shade (cooling effect)
- Improves microclimate

+ Recreational activities

Multifunctional area in Eitensheim used as a playground, sports field and with (rain) retention function @ Laura Hörner, LfU

Examples from Bavaria – Green Facades (10)

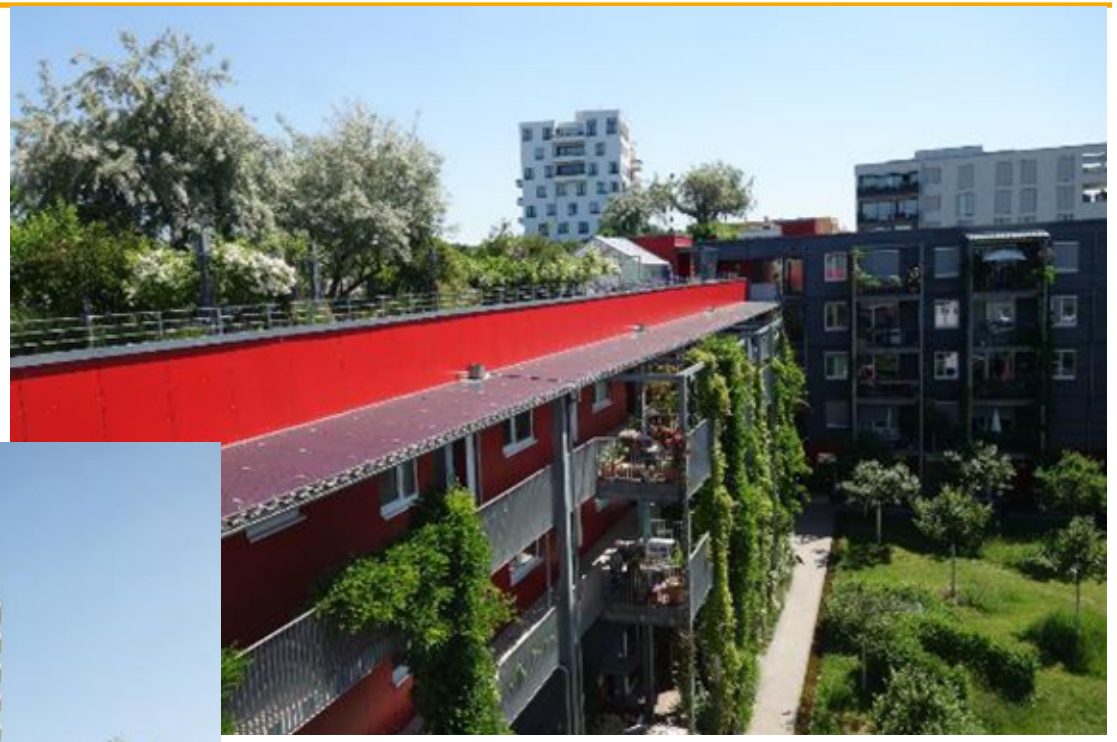
Description:

- Facade: Climbing plants (e.g. hydrangea, wild wine) or growing them in the facade
- Requires care

Climatic Effect:

- Cooling (building)
- Improves microclimate
- Improves biodiversity

+ Protection of facade



Green courtyard, roof and facade at Wagnis4, Munich © StMUV

Arabella Hochhaus in Munich (being built) © Schluchtmann Architekten München, Aika Schluchtmann

Examples from Bavaria – Green Roofs (11)

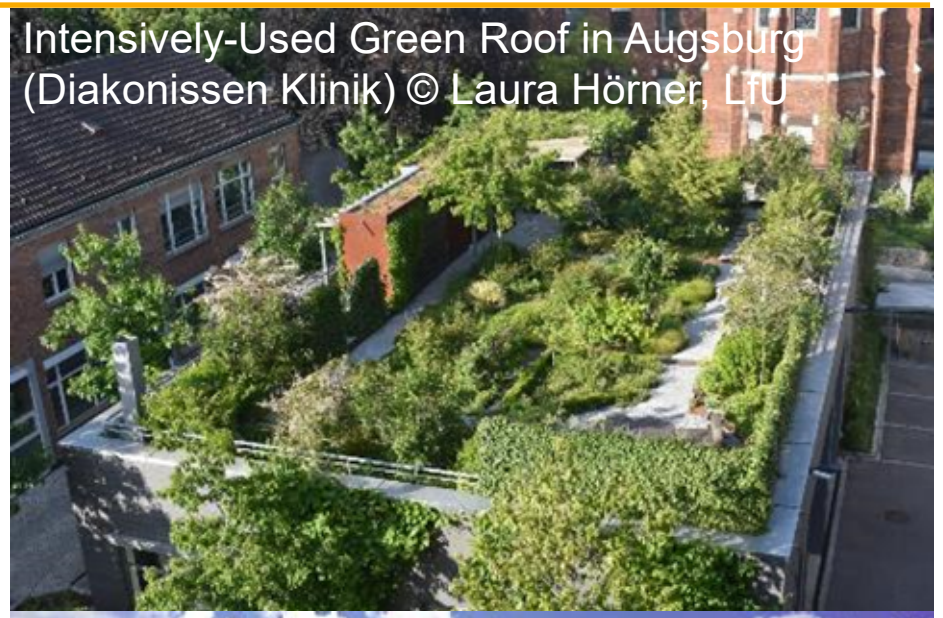
Description:

- Permeable layer of soil and plants, e.g. shrubs and trees
- Extras: Urban garden, playground, beehives, photovoltaic
- Intensive / extensive care depending on design
- Retention roof, where possible

Climatic Effect:

- Water retention (flood protection)
- Improves microclimate
- Cooling of building
- Improves biodiversity

+ Protection of roof



Intensively-Used Green Roof in Augsburg (Diakonissen Klinik) © Laura Hörner, LfU

Kneipp-Kindergarten in Achldorf © Lukas Vallentin

Examples from Bavaria – Cold Air Corridors (14,15)

Description:

- Wide, green corridors with low vegetation, e.g. grassy meadows or rivers
- Connect urban area and countryside to enable transport of cold (fresh) air into the city.

Climatic Effect:

- Improve aeration of urban area, especially at night (reduce urban heat island!)
- Increase fresh air supply (local wind systems)
- + Benefits human health

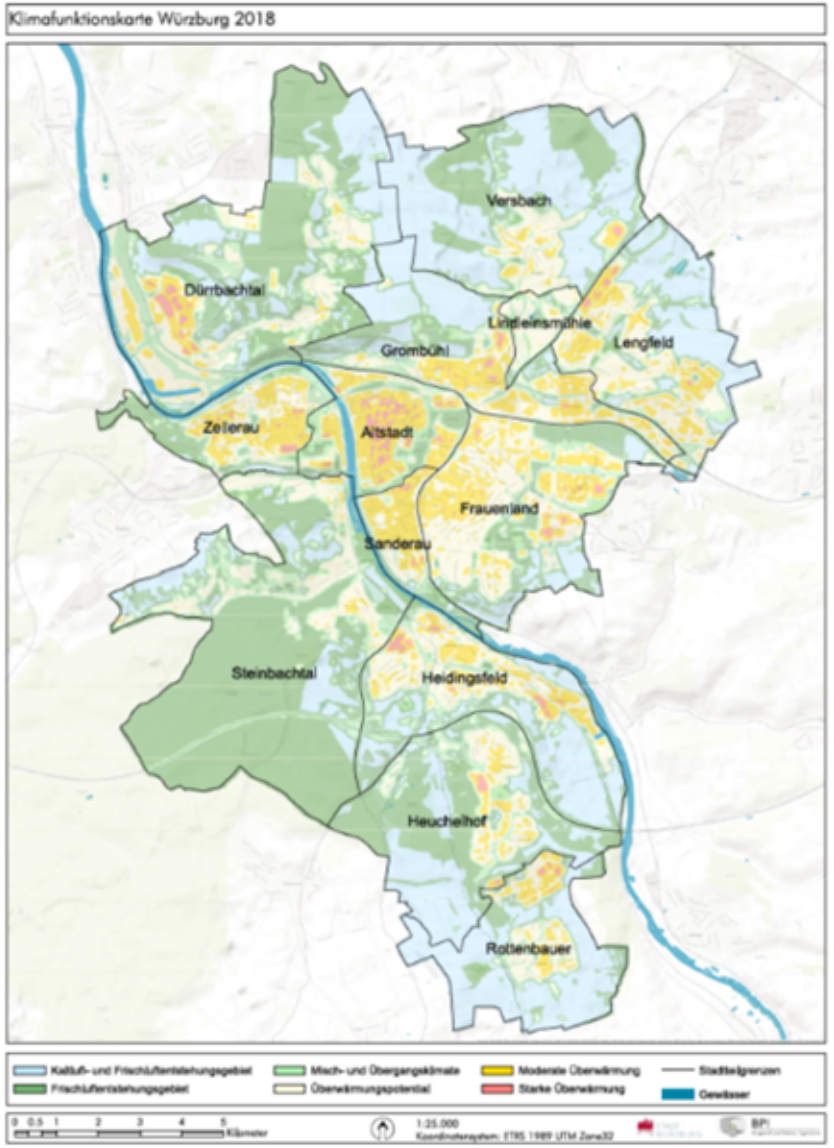
Wurzburg: Landesgartenschau Terrain (Gardening Exhibition) functions as cold-air corridor

Adaptation Strategies – Municipal Instruments

Strategic Planning

E.g. Wurzburg „climate functions map“

- Basis for Climate Adaptation Plan
- Map visualises urban heat islands and sources / corridors of cold air, such as the river Main
- University of Wurzburg is developing a more detailed model „Palm4U“ to show impact of buildings, trees etc.



Burghardt und Partner, Ingenieure (BPI), Kassel, www.lp-kassel.de

Adaptation Strategies – Municipal Instruments

From Concept to Development

E.g. Business Park, Garching

- Rain retention concept for new industrial area with rain retention pond, green facades, biodiversity-rich green areas
- Measures put into legally-binding development plan
- Implemented by Developers => model-character

E.g. Housing District „Prinz-Eugen Siedlung“, Munich

- Former military barracks bought by city
- Development plan: climate-friendly quarter with wooden buildings, green roofs, maintaining old trees and biodiversity-rich green areas

Rain Retention Concept in the Garching Business Park © Stefanie Schuster, LfU

Prinz-Eugen-Siedlung, Munich © BuGG

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Project „Stadt.Klima.Natur“ (= City.Climate.Nature),
an Initiative of the Bavarian Environment Ministry
stadtklimanatur.bayern.de

„To create climate-friendly and liveable cities of the future, we support municipalities in adapting to climate change with green and blue infrastructure! “

Interesting Links

- More information on instruments that enable municipalities to implement green and blue infrastructure: Broschure „*Instrumente für Klimaanpassung vor Ort*“ (DE) https://www.bestellen.bayern.de/shoplink/stmuv_klima_016.htm
- More information on blue infrastructure: Broschure „*Wassersensible Siedlungsentwicklung*“ (DE) – https://www.bestellen.bayern.de/shoplink/stmuv_wasser_018.htm
- Regional climate scenarios for Bavaria (past trends and future projections) – *Bavarian Climate Information System*: https://klimainformationssystem.bayern.de/
- More Information on climate change and adaptation on the LfU Homepage:
- https://www.lfu.bayern.de/klima/index.htm