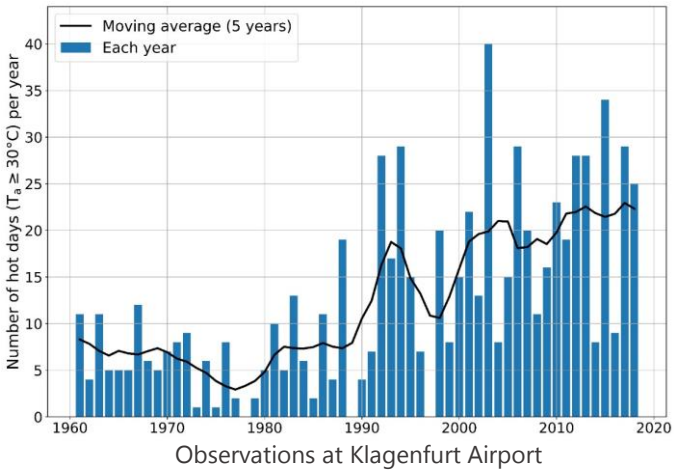
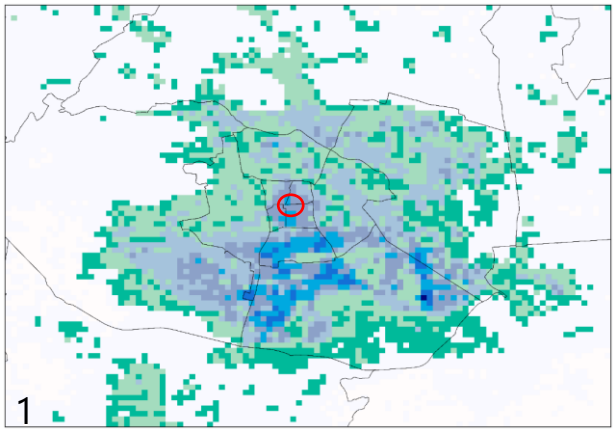
ADAPT URBAN HEAT ISLANDS — Climate Change Adaptation Scenarios for Klagenfurt

The average number of days per year where the air temperature reaches 30 °C (called hot days, HD) has increased considerably over the last decades. With climate change, this warming trend is expected to continue. Hence, climate adaptation measures are needed to reduce the heat load in the region of Klagenfurt.

Based on urban climate model results, the average value for the city is currently 12.5 HD, ranging from 2 HD in green areas and 21 HD in the city center. The effects of different adaptation measures in reducing the heat load were evaluated by comparing HD values with and without adaptation measures implemented in the model.





Scenario 1 (White City): Double the reflectivity of sealed surfaces (i.e., roofs, walls and streets/sidewalks). By using lighter-colored roofing materials or brighter concrete surfaces, more sunlight is reflected & less heat is absorbed.

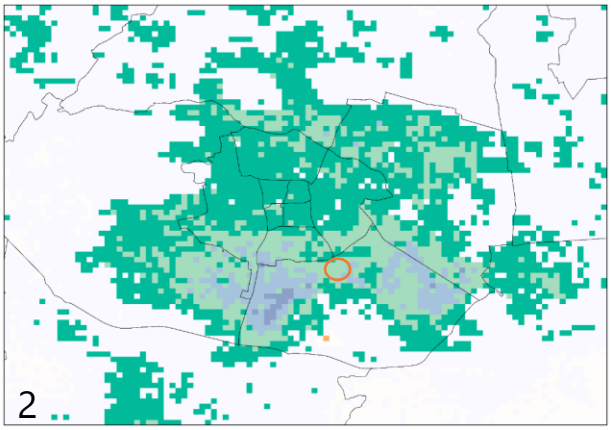
Key Findings

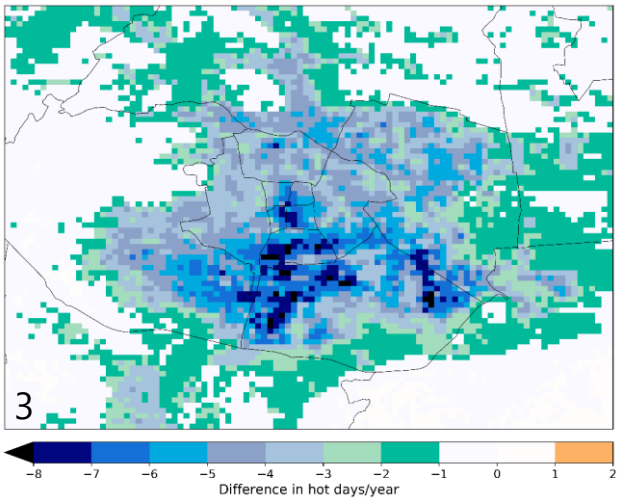
- ✓ Highest reduction is **7.3 HD**
- ✓ Neuer Platz would have **12 HD** instead of 16.1 HD

Scenario 2 (Green City): Increase in green surfaces to provide more evaporative cooling. Sealed areas are decreased by 30%, green roofs installed on 50% of roof areas, the number of trees is increased by 50% and bare soil replaced by grass.

Key Findings

- ✓Highest reduction is **4.7 HD**
- ✓Südpark Center would have **11.2 HD** instead of 14.3 HD





Scenario 3 (White and Green Combined): Increase in reflectivity of sealed surfaces and green surfaces combined. The 'cooling' effect is the largest, and almost the entire city shows a reduction in heat load by 3 HD or more.

Key Findings

- ✓ The highest reduction is **9.2 HD**
- ✓ Neuer Platz would have **10.8 HD** instead of 16.1 HD
- ✓ Südpark Center would have **8.8 HD** instead of 14.3 HD

For further information:

- ZAMG Urban Modelling – Scientific base for climate sensitive urban planning, ZAMG, 2017

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ADAPT URBAN HEAT ISLANDS

What Adaptation Measures are Implemented?

Different climate change adaptation measures can be implemented in a city. Below is a list of individual measures that were evaluated with the urban climate model and their grouping together to form Scenario 1 (White City – increasing reflectivity of surfaces), Scenario 2 (Green City – changing the evaporation of the surface) and Scenario 3 (Combined – reflective and green surfaces). The model results are shown in terms of the reduction in the percentage and number of hot days for each measure and scenario.

Adaptation Measure	Description	Illustration	Average Reduction in Hot Days	Largest Reduction in Hot Days
Double roof albedo	Increase the reflectivity of the roof, e.g., use lighter roofing materials		11.0% (1.4)	20.7% (4.0)
Double wall albedo	Increase the reflectivity of the wall, e.g., paint the wall a lighter color or use a lighter rendering		4.2% (0.5)	10.0% (2.0)
Double street albedo	Use more pervious, brightly-colored paving or paint the streets lighter colors		9.1% (1.1)	17.1% (3.3)
Decrease sealed areas	Implement grassland instead of paved areas in the city		5.8% (0.7)	12.2% (2.3)
Increase green roofs to 50%	Add green roofs to 50% of buildings in suburban areas of Klagenfurt	 1	5.3% (0.7)	17.1% (2.5)
Increase in number of trees by 50%	Plant more trees in public areas		2.3% (0.3)	20.2% (1.7)
Decrease unvegetated, pervious areas	Add grass to bare soil areas in the city		4.2% (0.5)	12.2% (2.2)
White City (Scenario 1)	Increase reflectivity of roofs, walls and streets	 2	25.2% (3.1)	37.8% (7.3)
Green City (Scenario 2)	Decrease sealed areas, add green roofs, increase trees and vegetated, pervious areas		15.8% (2.0)	26.6% (4.7)
Combination (Scenario 3)	Implement all adaptation measures from the White and Green City	 3	36.0% (4.5)	44.0% (9.2)

For further information:

- Stadtverkehrsflächen – Optimierter Beton für den innerstädtischen Bereich, Peyerl M., 2018
- Bäume kühlen Städte wie natürliche Klimaanlagen, botanikguide.de, 2018
- Weiße Dächer kühlen heiße Städte, n-tv.de, 2019
- Warum Wien mehr grüne Dächer braucht, energieleben.at, 2019

Photographs

1. Flickr @Grand River Conservation Authority
2. Flickr @Harvey Barrison
3. https://talkofthecities.iclei.org/paradoxes-of-a-smart-city-3-open-data-vs-data-management/

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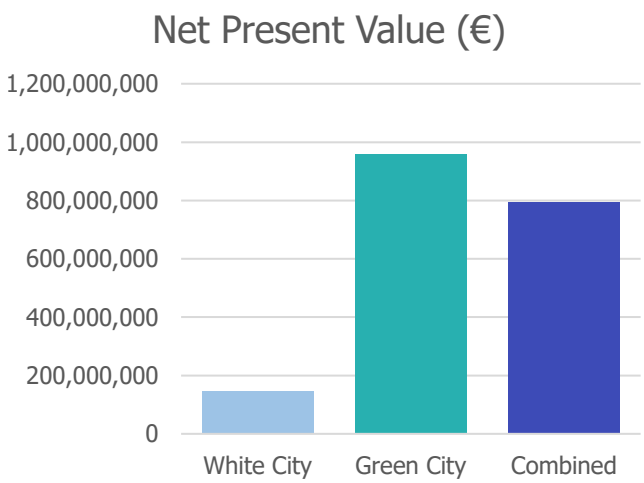
A Cost-Benefit Analysis of Climate Change Adaptation for Klagenfurt

A cost-benefit analysis involves comparing the costs of implementing climate change adaptation measures with the benefits that these measures produce. We can quantify the benefits in monetary terms by taking reduced mortality, hospitalization and worker productivity loss as well as numerous ecosystem services such as habitat creation, stormwater management, heating and cooling savings, pollution and carbon reduction, improved aesthetics and longevity of buildings into account.

A cost-benefit analysis was undertaken for Scenario 1 (White City), Scenario 2 (Green City) and Scenario 3 (White and Green combined) for the city of Klagenfurt. The results show that Scenarios 2 and 3 yield the highest benefits to society. Scenario 1 also results in benefits such as reduced mortality, morbidity and worker productivity loss, but no other societal and ecological issues are addressed with this scenario.

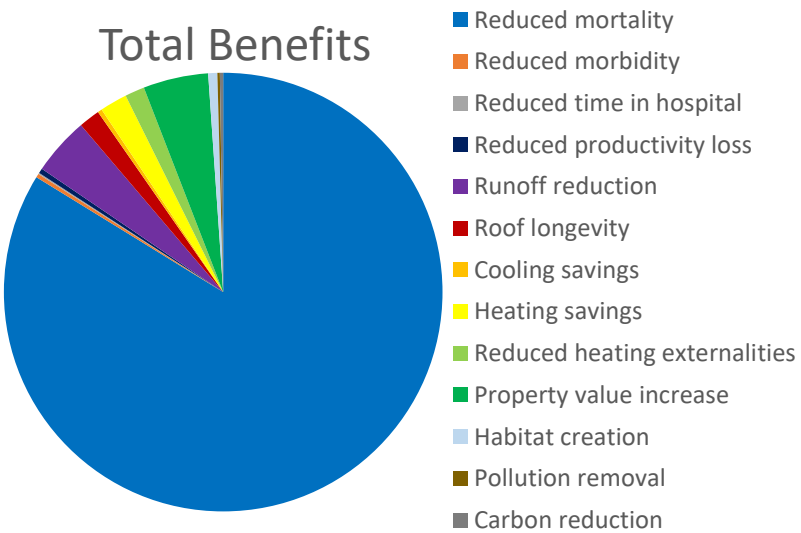


The main indicator for the cost-benefit analysis is the **Net Present Value**.

Net Present Value = total present value of all benefits minus the present value of all costs discounted over a 50-year time horizon.

Both Scenario 2 (Green City) and Scenario 3 (Green and White combined) result in high net present values. Thus, both scenarios indicate large **net benefits to society**.

To the right, we show the total benefits for Scenario 3 (Green and White combined).



Key Findings

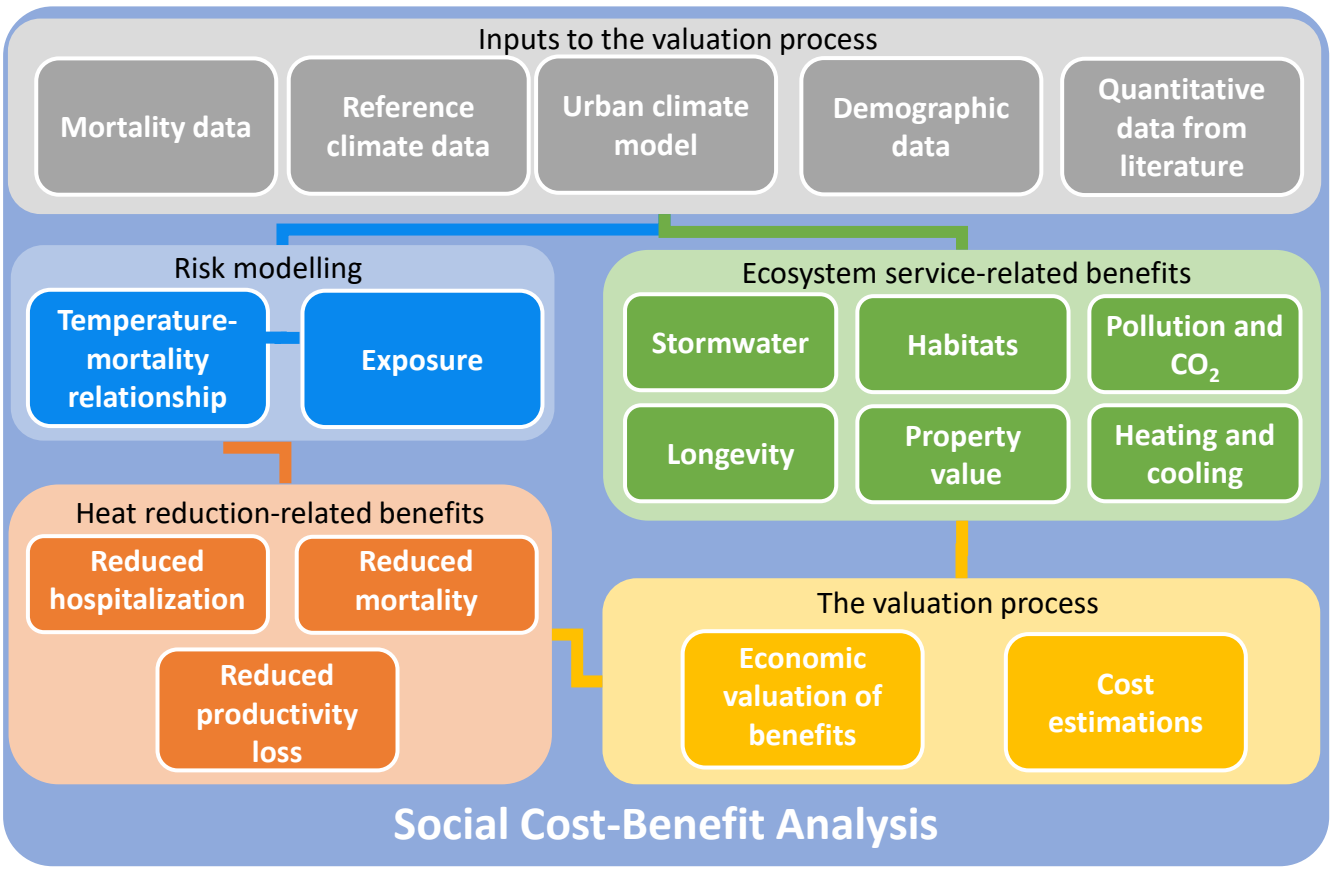
- ✓ Reduced heat-related mortality results in the highest benefits to society.
- ✓ The increased provision of ecosystem services results in €471 million or 15% of the total benefits for Klagenfurt.

By implementing climate change adaptation measures, particularly those associated with the Green City such as surface unsealing and the addition of green roofs, trees and vegetated areas, Klagenfurt can aid stormwater management, increase biodiversity, reduce heating and cooling costs, reduce pollution and carbon emissions, and increase the value of buildings and their longevity. These are all benefits that the residents of Klagenfurt will value in the future.

How do we Value the Benefits of Climate Change Adaptation?

Below we illustrate how **social cost-benefit analysis** is undertaken, in particular how we value the benefits associated with the implementation of climate change adaptation measures.

We start with input data from a variety of sources including mortality, climate and demographic data. We then use these inputs to produce a temperature-mortality relationship from which we can quantify the exposure of Klagenfurt residents to extreme heat.



We then consider two main types of benefits. The first are **heat-related benefits**, which include reduced mortality, hospitalization and worker productivity loss. We calculate the economic benefits as a result of the reduction in the number of hot days after implementing climate adaptation measures. For example, on a hot day, worker productivity is reduced by around 7% on average. With an average reduction of 0.94 hot days in a year, Klagenfurt saves an estimated €520,000 in annual gross regional product while €11 million is saved in hospitalization costs.

The second are **ecosystem service-related benefits**, which result from the implementation of green measures such as green roofs, unsealing of paved surfaces, adding more trees and vegetated areas, etc. For Scenario 3 (Green and White City combined), we have determined the value of the ecosystem service benefits for Klagenfurt over the next 50 years as follows:

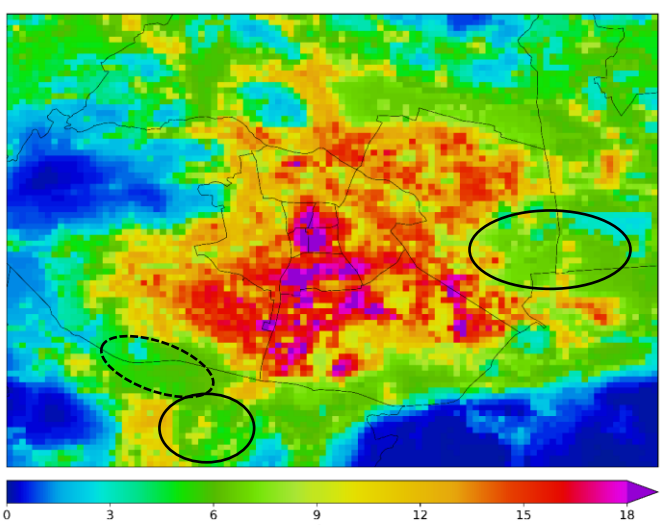
- ✓ € 130 million in reduced stormwater runoff
- ✓ € 47 million in reduced replacements of roofs due to the longevity of green roofs
- ✓ € 146 million in increased property values
- ✓ € 20 million in additional habitat space
- ✓ € 13 million in pollution and carbon dioxide (CO_2) reduction
- ✓ € 115 million in heating and cooling savings

We then calculate the costs associated with the adaptation measures and compare these to the total value of all benefits. For Klagenfurt, implementing climate change adaptation measures is beneficial!

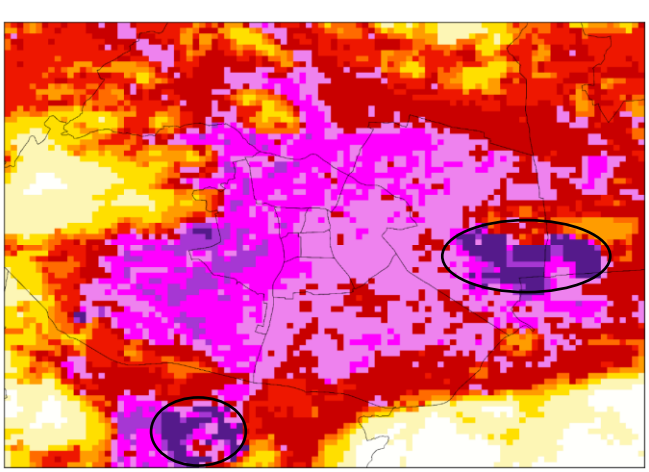
Extending Climate Change Adaptation to Future Climate Scenarios and Future Building Plans

Future projections indicate substantial growth rates in urbanization (UN, 2018) and a continued global warming (IPCC, 2013), dependent on the Representative Concentration Pathway (RCP) chosen. Hence, the urban heat load and the related negative impacts of the Urban Heat Island are expected to intensify in the future.

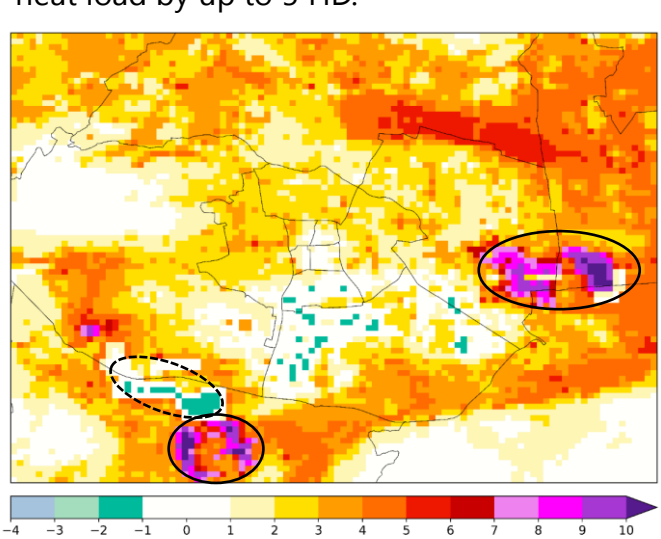
To estimate possible future urban climate scenarios, we used model outputs from different Regional Climate Models under RCP4.5 (the scenario in which CO_2 emissions are set to peak by 2040) for the time period 2021-2050 (as defined in the IPCC report). IPAK also provided a future building plan for the region of Klagenfurt. New buildings (i.e., residential and commercial) will be constructed and afforestation implemented mainly in the eastern and southern (Viktring) part (marked with black ellipses in the figures). The figure on the left shows the absolute values for HD for 1981-2010.



The figure in the middle shows the increase in HD for RCP4.5. While the increase in urban areas (inner districts) is quite similar, the increase is enhanced where new buildings are planned (black ellipses, which were previously annual crops).



The figure below shows the effect of the combined adaptation measures (Scenario 3) implemented with current as well as future planned buildings. The intensity and spatial extent of the cooling is quite pronounced - the entire southern part of the city remains at the current level of HD. Moreover, the sustainable construction methods associated with the new planned buildings mitigate the heat load by up to 5 HD.



Key Findings

- ✓ The city of Klagenfurt remains at around the **same level of HD** in 1981-2010 until 2050 if the combined adaptation measures are implemented
- ✓ Future building plans will increase the number of HD, but the sustainable construction methods will mitigate the urban heat load

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