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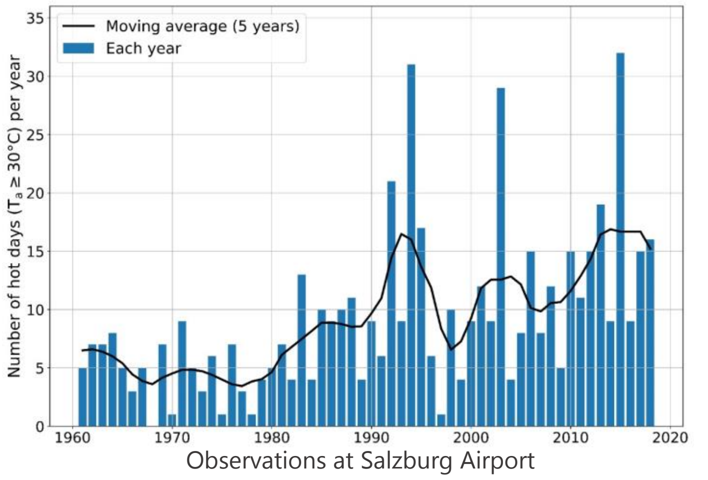
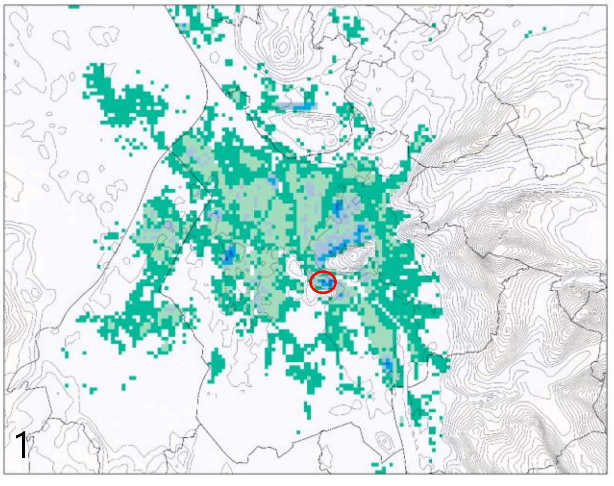
Climate Change Adaptation Scenarios for Salzburg

The average number of days per year where 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 Salzburg.

Based on urban climate model results, the average value for the period 1981-2010 is 4.9 HD, ranging from 0.3 HD in green areas and 12.4 HD in the city center. The effects of different adaptation measures in reducing the heat load were evaluated by comparing HD values with or 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.

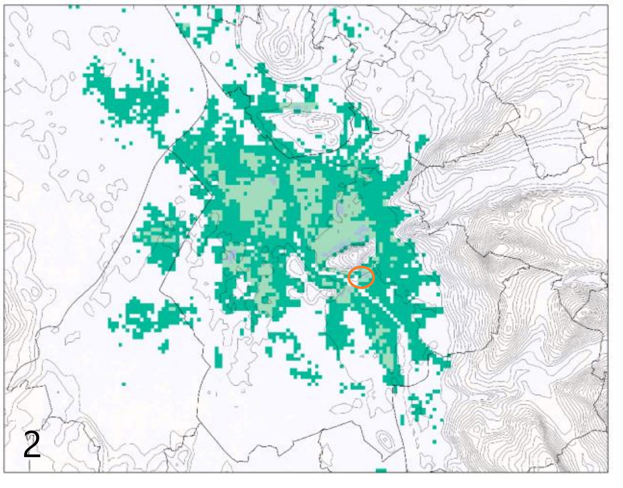
Key Findings

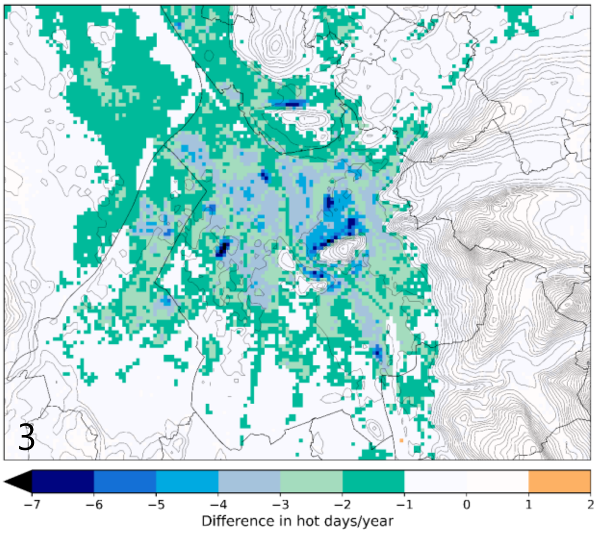
- ✓ Highest reduction is **5.6 HD**
- ✓ Getreidegasse would have **4.9 HD** instead of 10 HD

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, number of trees increased by 50% and bare soil replaced by grass.

Key Findings

- ✓ Highest reduction is **4.0 HD**
- ✓ Volksgarten would have **4.4 HD** instead of 7.2 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 **7.5 HD**
- ✓ Getreidegasse would have **4.0 HD** instead of 10 HD
- ✓ Volksgarten would have **2.6 HD** instead of 7.2 HD

For further information:

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

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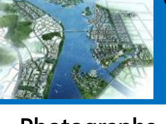
What Adaptation Measures are Implemented?

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		28.5% (1.4)	32.2% (3.8)
Double wall albedo	Increase the reflectivity of the wall, e.g., paint the wall a lighter color or use a lighter rendering		17.8% (0.9)	24.1% (2.7)
Double street albedo	Use more pervious, brightly-colored paving or paint the streets lighter colors		16.2% (0.8)	25.5% (2.7)
Decrease sealed areas	Implement grassland instead of paved areas in the city		16.8% (0.8)	20.0% (2.2)
Increase green roofs to 50%	Add green roofs to 50% of buildings in suburban areas of Salzburg	 a	22.1% (1.1)	27.9% (3.1)
Increase in number of trees by 50%	Plant more trees in public areas		15.3% (0.7)	29.7% (1.9)
Decrease unvegetated, pervious areas	Add grass to bare soil areas in the city		14.4% (0.7)	26.5% (1.8)
White City (Scenario 1)	Increase reflectivity of roofs, walls and streets	 b	38.2% (1.8)	47.5% (5.6)
Green City (Scenario 2)	Decrease sealed areas, add green roofs, increase trees and vegetated, pervious areas		33.1% (1.6)	33.9% (4.0)
Combination (Scenario 3)	Implement all adaptation measures from the White and Green City	 c	55.2% (2.7)	70.1% (7.5)

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

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

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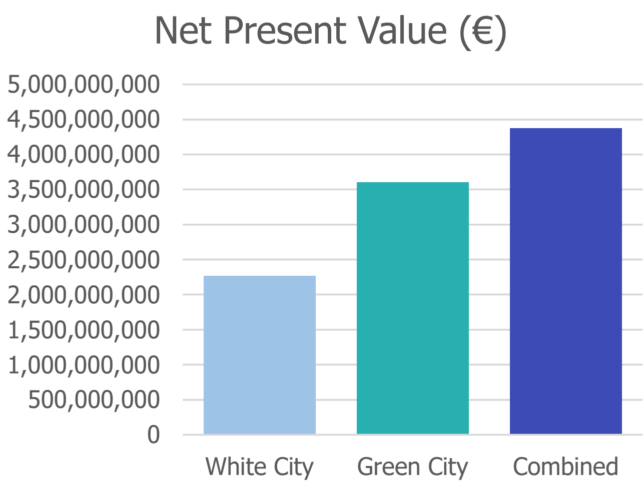
A Cost-Benefit Analysis of Climate Change Adaptation for Salzburg

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 Salzburg. 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.

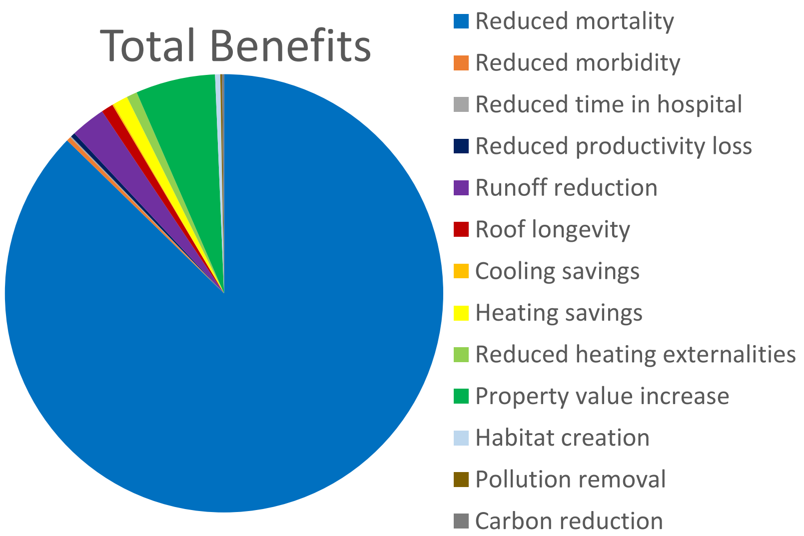


The main indicator for the cost-benefit analysis is the **Net Present Value**.

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 €837 million or 12% of the total benefits for Salzburg.

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, Salzburg 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 Salzburg will value in the future.

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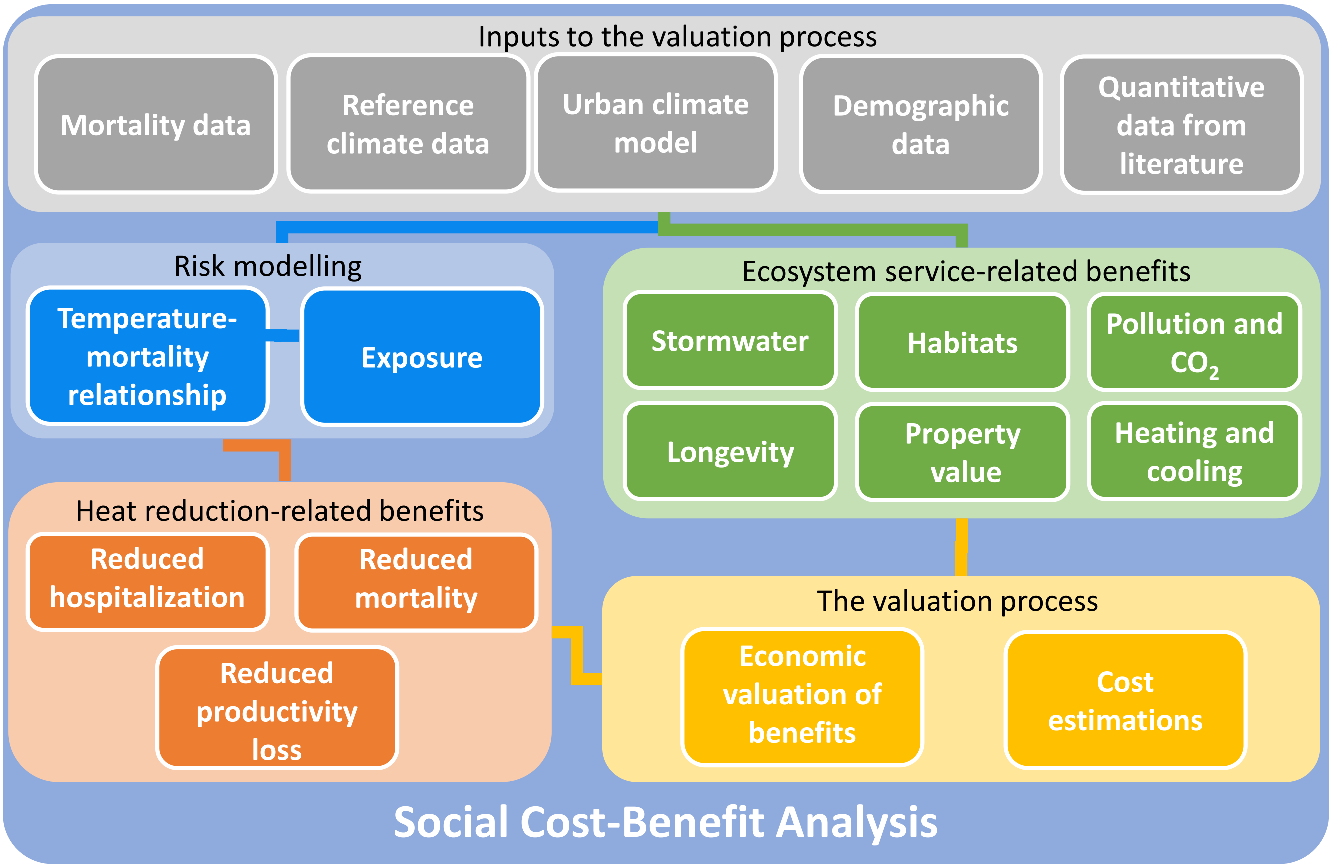
How do we Value the Benefits of Climate Change Adaptation?

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 Salzburg 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 0.96 hot days in a year, Salzburg saves an estimated €1.1 million in annual gross regional product while €29 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 Salzburg over the next 50 years as follows:

- ✓ € 180 million in reduced stormwater runoff
- ✓ € 62 million in reduced replacements of roofs due to the longevity of green roofs
- ✓ € 410 million in increased property values
- ✓ € 27 million in additional habitat space
- ✓ € 19 million in pollution and carbon dioxide (CO_2) reduction
- ✓ € 139 million in heating and cooling savings (and externalities of heat savings)

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

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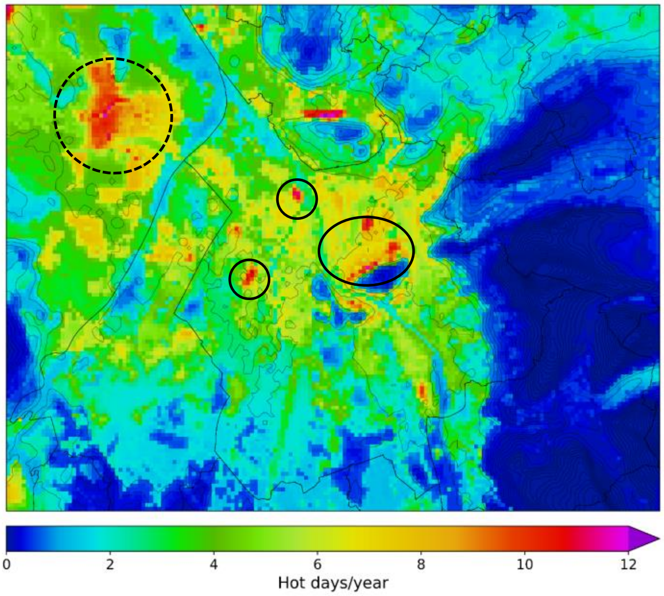
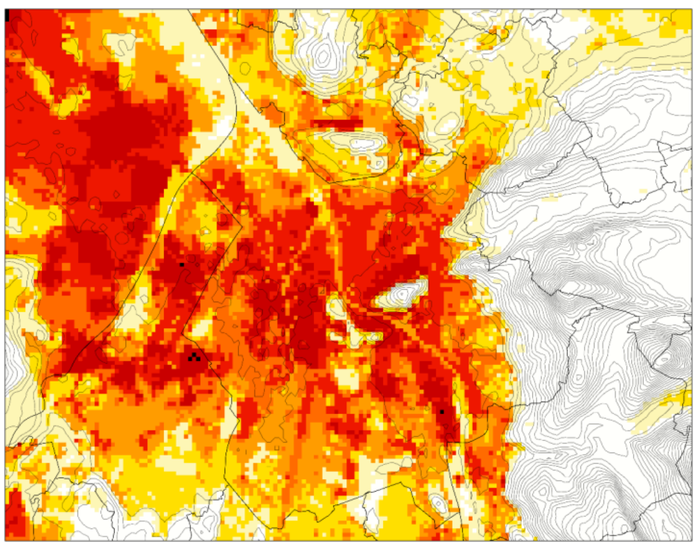
Extending Climate Change Adaptation to Future Climate Scenarios and Future Building Plans

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.

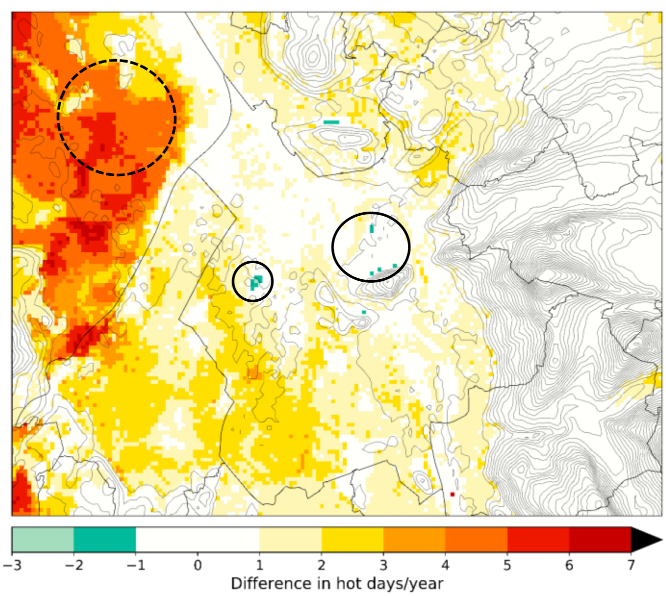
To estimate possible future urban climate scenarios, we used model outputs from different Regional Climate Models under RCP4.5 (the scenario in which CO_2 emissions are set to peak by 2040) for the time period 2021-2050 (as defined in the IPCC report).



The figure on the left shows the absolute values for HD for 1981-2010. While most parts of the city reach values between 4 and 8 HD, single areas such as the Messezentrum, the commercial area in the East and parts of the city center (black circles) stand out with 10 HD and above. The figure in the middle shows the increase in HD for RCP4.5. Fortunately, green urban areas such as the Kapuziner- and Mönchsberg stay at the same level of HD without any adaptation measures, but almost the whole city increases by up to 6 HD (60 - 90% more).



The figure below shows the effect of the combined adaptation measures (Scenario 3) implemented with current buildings. The intensity and spatial extent of the cooling is quite pronounced – almost the entire city remains at the current level of HD. Furthermore, the previously mentioned dense urban areas become a little bit cooler than today.



Key Findings

- ✓ The city of Salzburg remains at around the **same level of HD** in 1981-2010 until 2050 if the combined adaptation measures are implemented.
- ✓ Future scenarios shows that **dense urban areas** (Schallmooser Hauptstraße, Reithofferstraße) **can be even lower** (i.e., cooler) than the current heat load.
- ✓ **Freilassing** (Germany) also has lower values in HD, demonstrating that **transnational cooperation** would be beneficial.

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