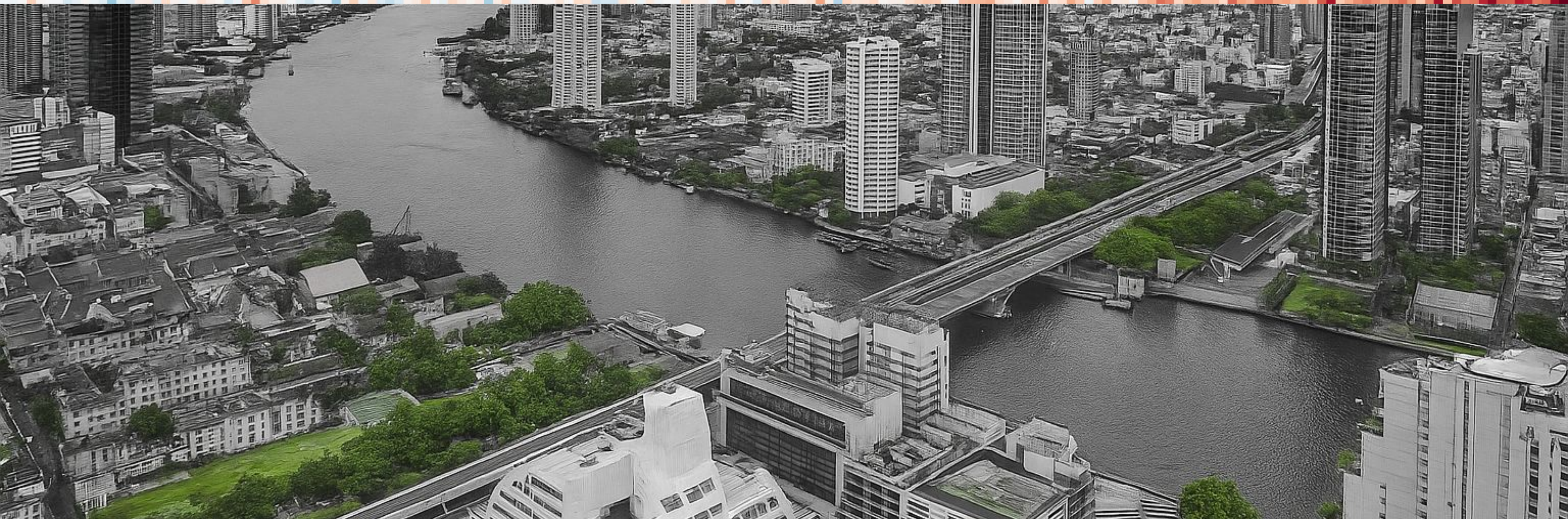
Microclimate heat modeling:
Case study area of Bangkok - Thailand

B-Kode

Dr. Matthias Demuzere & Dr. Kerry Nice*
www.b-kode.be



B-Kode's role

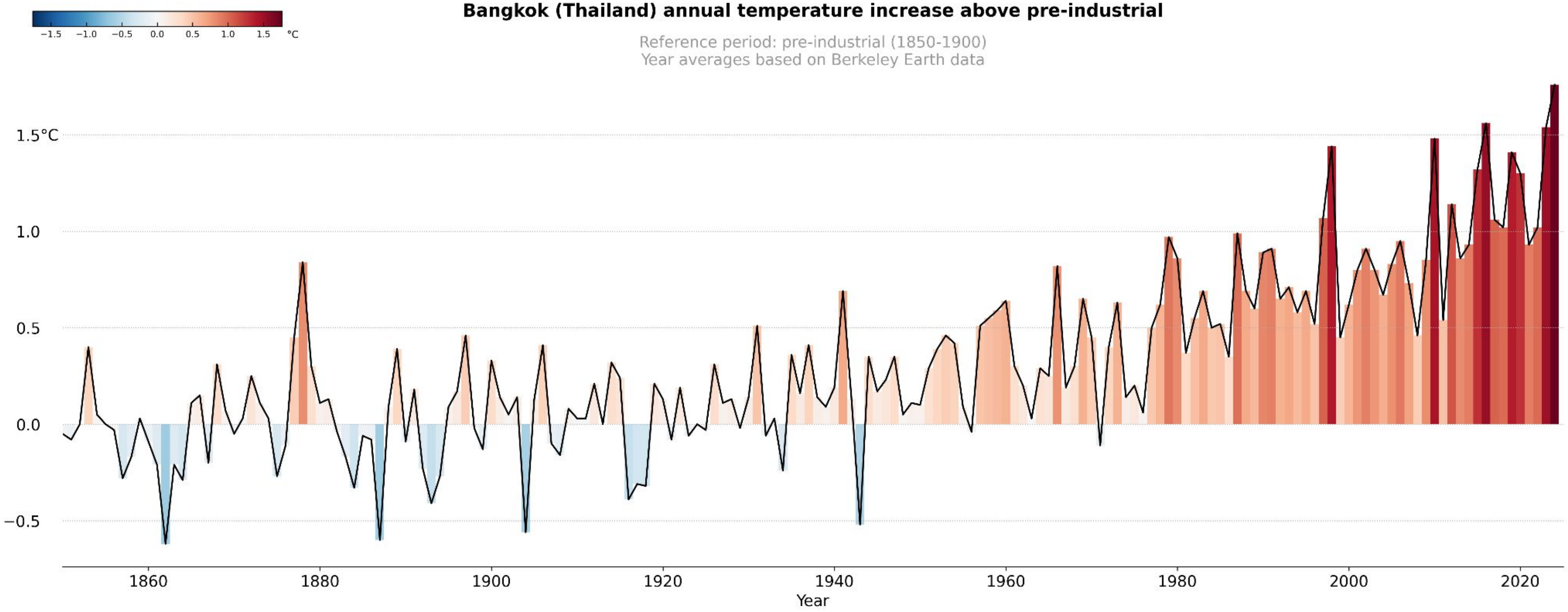
Urban Heat Risk Assessment
Analysis of historical urban heat patterns in Bangkok, identifying strong spatial differences in heat exposure — with central districts facing the highest risk in terms of intensity, frequency, and duration of heatwaves.

Modeling Climate Projections
Simulate future conditions to project how urban heat and heatwaves will evolve by mid-century under moderate emission scenarios, showing that all districts will experience worsening conditions.

Scenario-Based Intervention Modeling
Simulated a *Nature-Based Solutions (NBS)* scenario, integrating green infrastructure, urban tree canopy, water-sensitive design, and permeable surfaces — resulting in measurable reductions in heatwave days (up to 24 fewer), duration (30+ days shorter), and severity (cooling up to 0.4°C).

Strategic Guidance for Adaptation
Proposed a multi-pronged urban resilience strategy that combines NBS with heat-resilient planning, infrastructure reforms, early warning systems, and targeted interventions for vulnerable populations.

Context



−1.5 −1.0 −0.5 0.0 0.5 1.0 1.5 °C
Bangkok (Thailand) annual temperature increase above pre-industrial
Reference period: pre-industrial (1850-1900)
Year averages based on Berkeley Earth data
1.5°C
1.0
0.5
0.0
−0.5
1860
1880
1900
1920
1940
1960
1980
2000
2020
Year

Methodology

Inputs

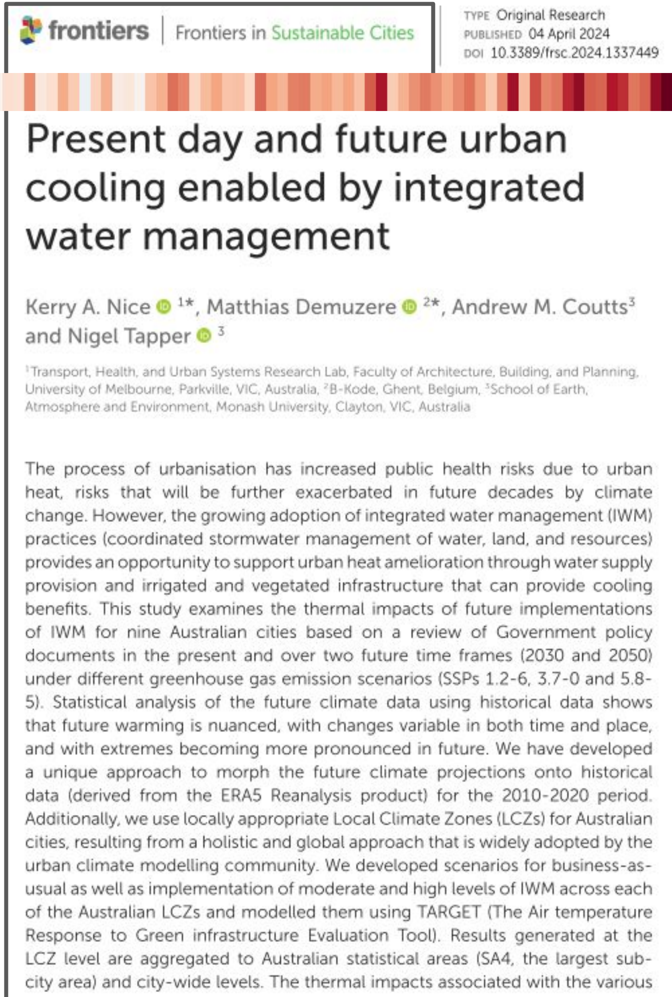
- Present-day (1985-2014) and future (2036-2065, SSP2-4.5) atmospheric forcing based on reanalysis and CMIP6 global climate projections
- Present-day land-cover and nature-based heat mitigation strategies based on Local Climate zones

Tools

- TARGET model, the Air-temperature Response to Green/blue-infrastructure Evaluation Tool
- Heatwave definition: at least three consecutive days where daily Tmean exceeds the 95th percentile of the historical temperature distribution in the city's coolest district during the February to July period from 1985 to 2014 (a threshold of ~ 29.8°C).

Outputs

- Past and future heatwave trends in Bangkok's districts
- Dampening heatwaves through nature-based solutions



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Present day and future urban cooling enabled by integrated water management

Kerry A. Nice [1*], Matthias Demuzere [2*], Andrew M. Coutts[3] and Nigel Tapper [3]

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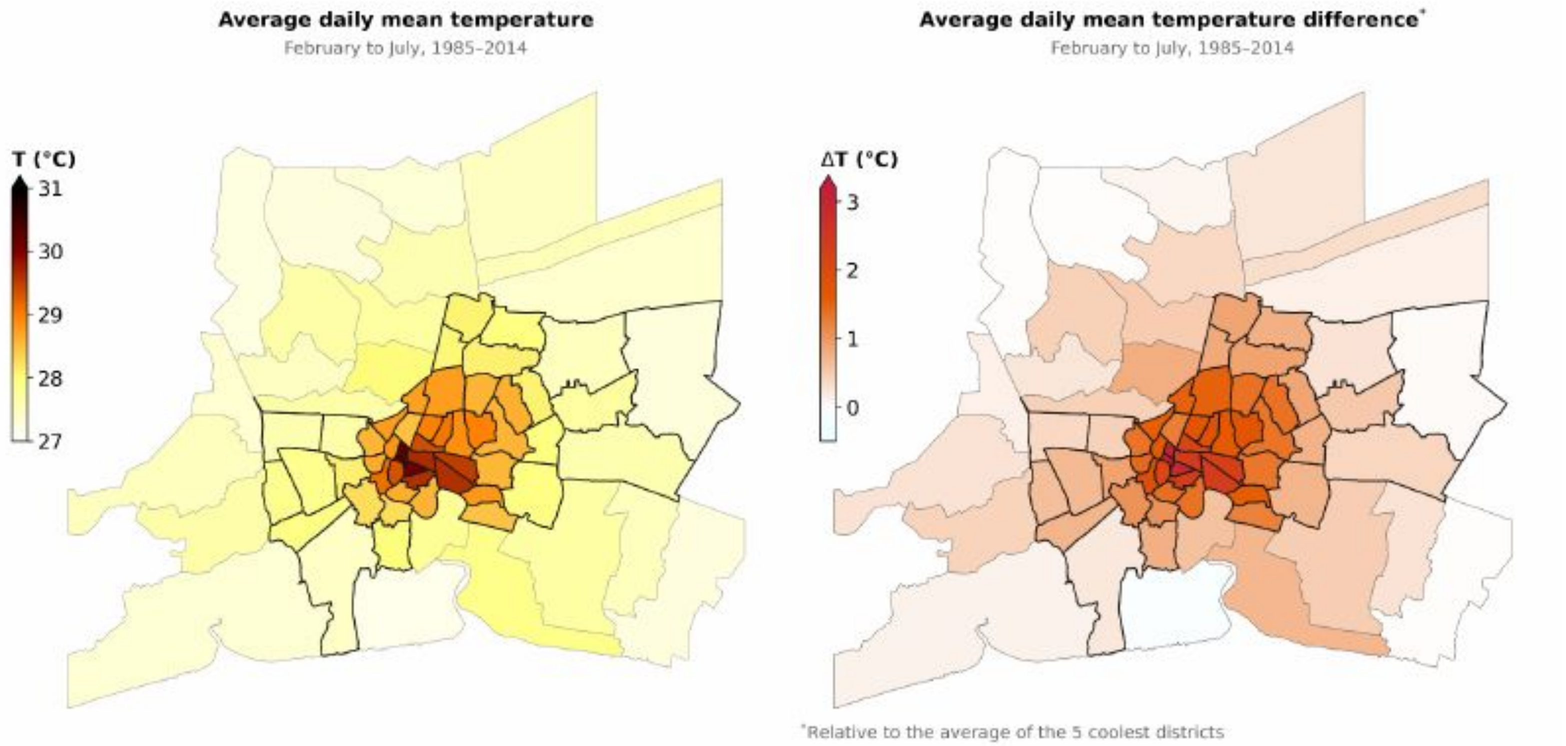
The process of urbanisation has increased public health risks due to urban heat, risks that will be further exacerbated in future decades by climate change. However, the growing adoption of integrated water management (IWM) practices (coordinated stormwater management of water, land, and resources) provides an opportunity to support urban heat amelioration through water supply provision and irrigated and vegetated infrastructure that can provide cooling benefits. This study examines the thermal impacts of future implementations of IWM for nine Australian cities based on a review of Government policy documents in the present and over two future time frames (2030 and 2050) under different greenhouse gas emission scenarios (SSPs 1.2-6, 3.7-0 and 5.8-5). Statistical analysis of the future climate data using historical data shows that future warming is nuanced, with changes variable in both time and place, and with extremes becoming more pronounced in future. We have developed a unique approach to morph the future climate projections onto historical data (derived from the ERA5 Reanalysis product) for the 2010-2020 period. Additionally, we use locally appropriate Local Climate Zones (LCZs) for Australian cities, resulting from a holistic and global approach that is widely adopted by the urban climate modelling community. We developed scenarios for business-as-usual as well as implementation of moderate and high levels of IWM across each of the Australian LCZs and modelled them using TARGET (The Air temperature Response to Green infrastructure Evaluation Tool). Results generated at the LCZ level are aggregated to Australian statistical areas (SA4, the largest sub-city area) and city-wide levels. The thermal impacts associated with the various

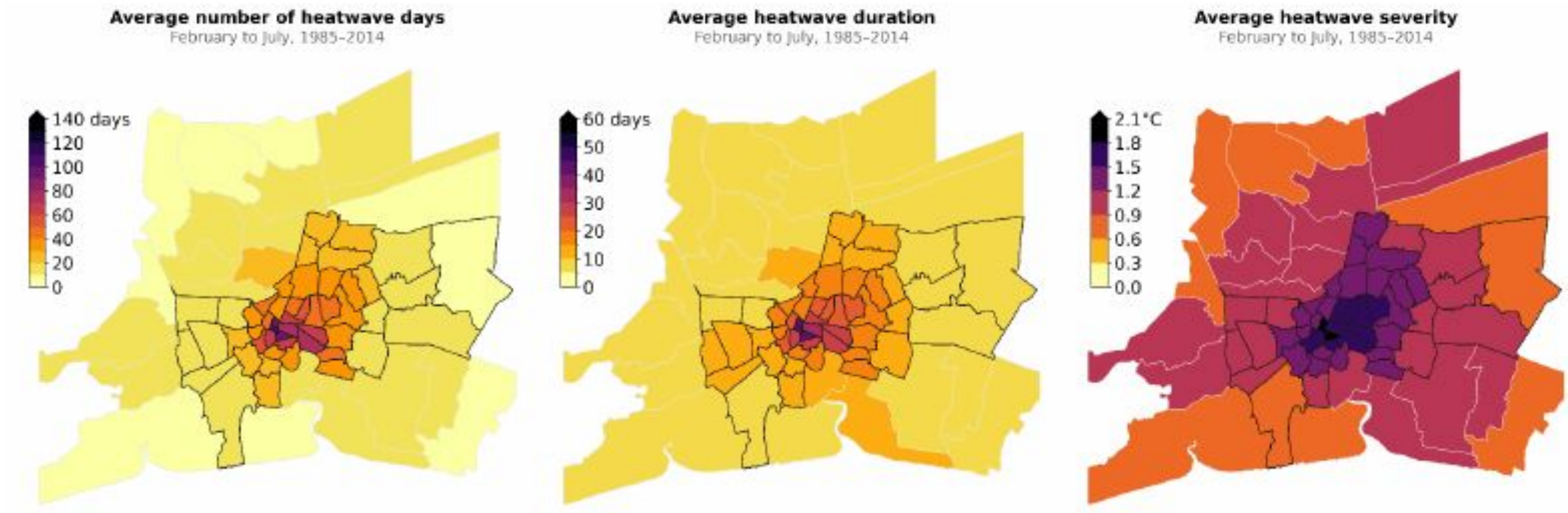
Present-day urban overheating



Notes: The five coolest districts are white-colored in the right panel, and are Sai Noi (THA.36.6_1), Lat Lum Kaeo (THA.37.3_1), Phra Samut Jadee (THA.57.6_1), Bang Bo (THA.57.1_1), Nong Chok (THA.3.28_1). Values in brackets refer to the GID_2 id from the gadm database.
Source: B-Kode analysis based on TARGET simulations.

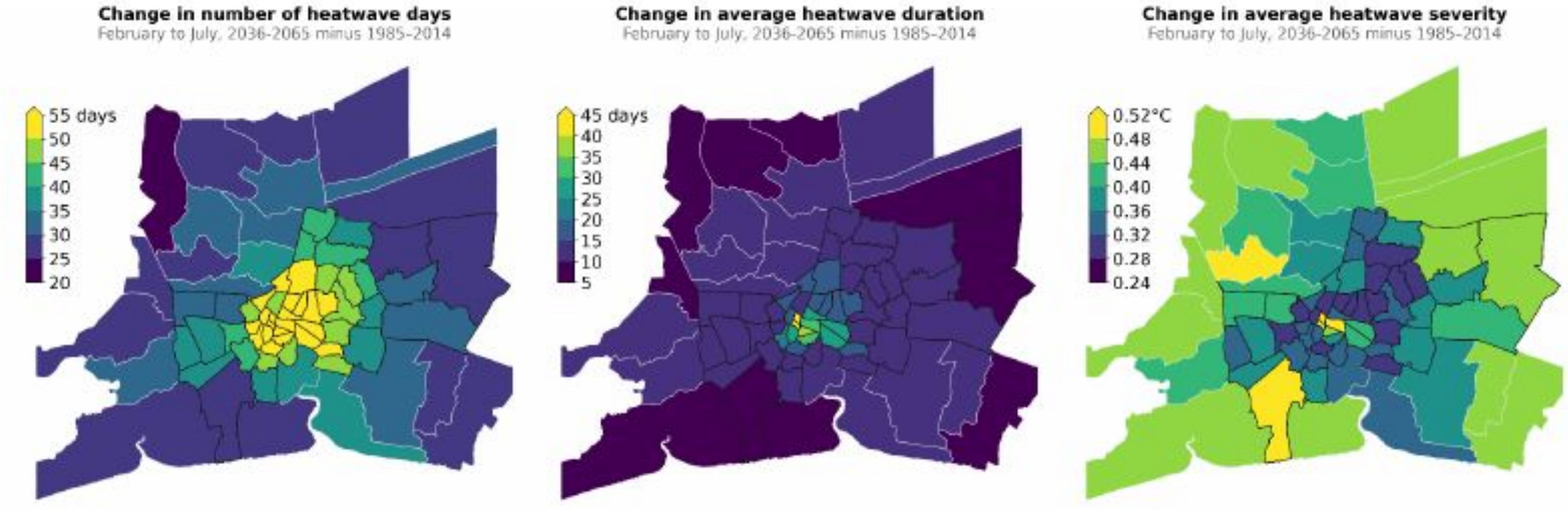
Results

Present-day heatwave characteristics



Source: B-Kode analysis based on TARGET simulations.

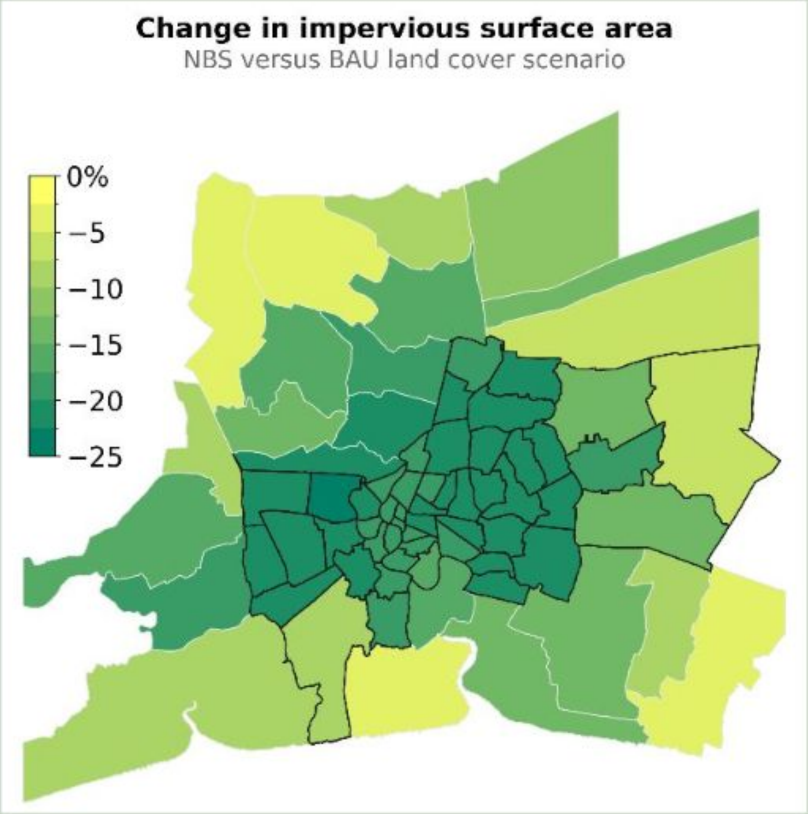
Projected changes in heatwave characteristics by mid-century



Notes: Changes are calculated as the difference between the heatwave characteristics averaged for 2036-2065 SSP2-4.5 and the historical period 1985-2014.
Source: B-Kode analysis based on TARGET simulations.

Results

Reductions of impervious surfaces using NBS



The Nature-Based Solutions scenario modeled in Bangkok introduced a comprehensive transformation of urban land cover by prioritizing vegetation, water retention, and cooling design strategies, leading to a notable decrease in impervious surface area.

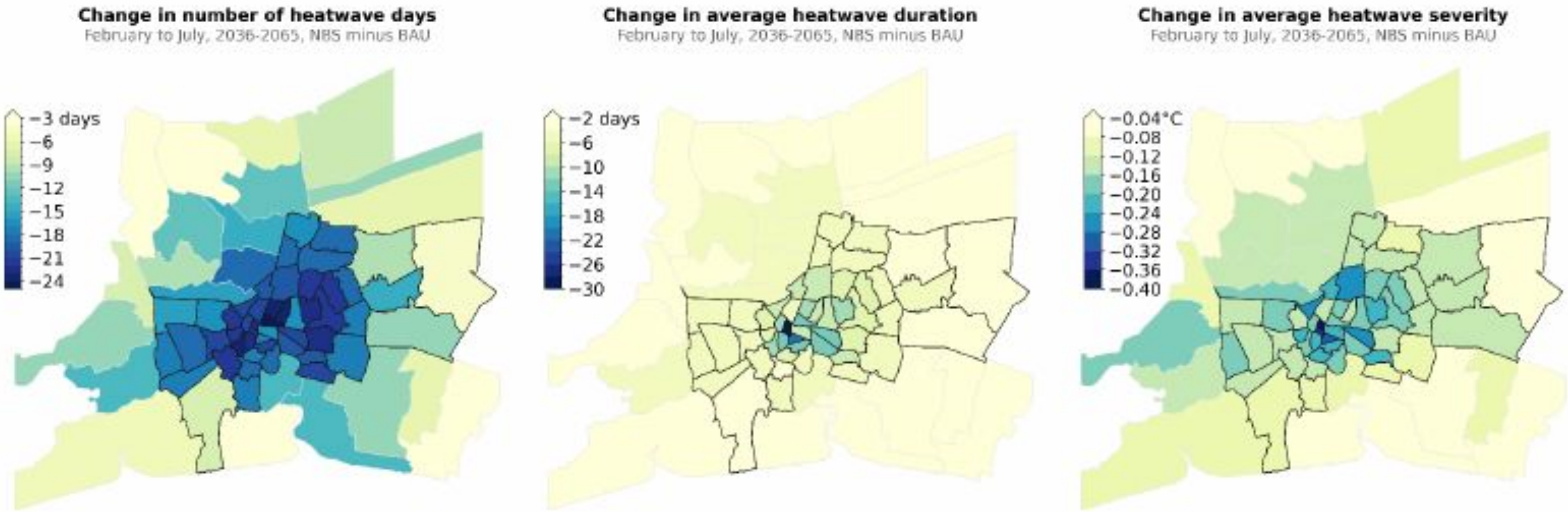
Urban Tree Canopy Expansion
Increases shade, reduces surface temperatures, and enhances evapotranspiration.

Water-Sensitive Urban Design
Includes rain gardens, swales, wetlands, and irrigation to retain and manage moisture.

Green Infrastructure
Parks, green roofs, and vegetated corridors that buffer heat and improve natural ventilation.

Permeable Surfaces
Replaces concrete with grass or planted areas, allowing cooling and water absorption.

Projected heatwave characteristics dampened by NBS



Source: B-Kode analysis based on TARGET simulations.

Results

Summary

Targeted nature-based interventions across Bangkok lead to significant reductions in future urban heat risks compared to the business-as-usual scenario urban land cover — particularly in the most heat-affected districts, where dense urban form and limited green space currently amplify heat exposure.

Fewer Heatwave Days

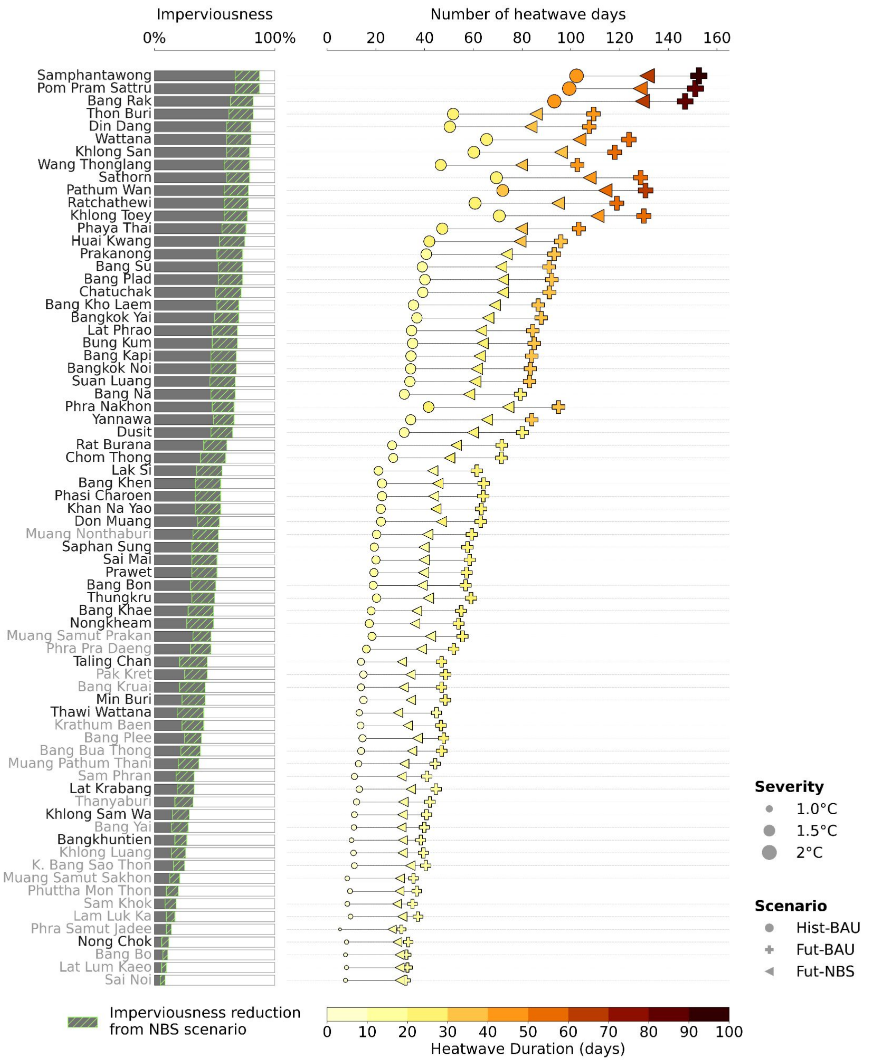
- Up to 24 days fewer per season
- Biggest improvements in central & western districts

Shorter Heatwave Duration

- Reductions of 30+ days in urban hotspots
- Less time spent under extreme heat stress

Lower Heatwave Severity

- Cooling of up to 0.4°C during extreme events
- Strongest effect in densely built-up areas



The Way Forward: Building a Heat-Resilient Bangkok

> Nature-Based Solutions offer a measurable buffer against rising urban heat — but they must be paired with bold planning and social protection measures to build a safer, more equitable, and livable Bangkok.

Expand Nature-Based solutions
Scale up trees, parks, green roofs, and water-sensitive design in priority districts

Integrate Heat Resilience into Urban Planning
Embed cooling strategies into building codes, zoning, and development policies

Strengthen Heat Risk Response
Establish early warning systems, community cooling centers, and hydration stations

Prioritize Equity & Inclusion
Focus interventions where exposure and vulnerability are highest

More information?

Technical report (26p)

TECHNICAL REPORT
Urban heat modeling & NBS scenario analysis

Technical Report
Urban heat modeling & NBS scenario analysis

contributing to

Urban Heat Resilience:
Bridging Science, Policy, and Sustainable Design

Funded by:

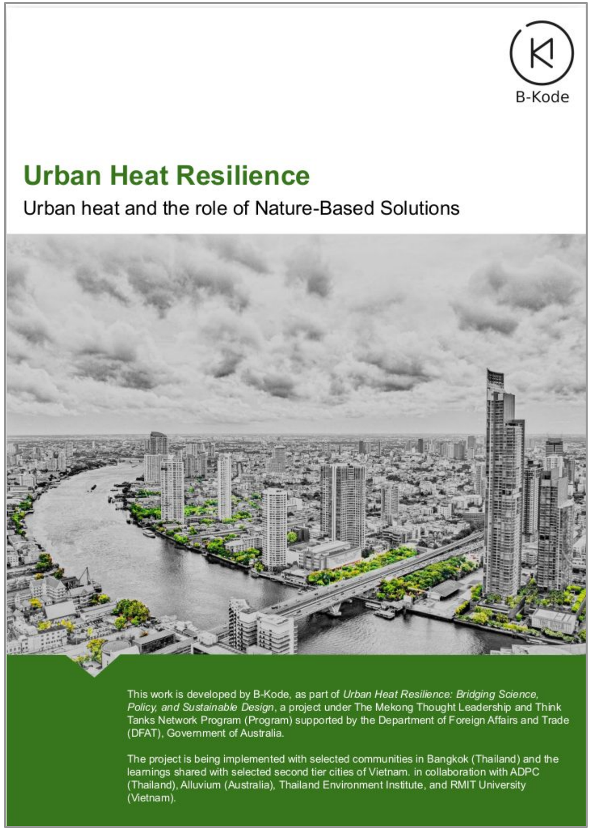
Australian Government
Department of Foreign Affairs and Trade

SEI

Dr. Matthias Demuzere
Dr. Kerry Nice

B-Kode

Communication leaflet (4p)



B-Kode

Urban Heat Resilience
Urban heat and the role of Nature-Based Solutions

This work is developed by B-Kode, as part of *Urban Heat Resilience: Bridging Science, Policy, and Sustainable Design*, a project under The Mekong Thought Leadership and Think Tanks Network Program (Program) supported by the Department of Foreign Affairs and Trade (DFAT), Government of Australia.

The project is being implemented with selected communities in Bangkok (Thailand) and the learnings shared with selected second tier cities of Vietnam. in collaboration with ADPC (Thailand), Alluvium (Australia), Thailand Environment Institute, and RMIT University (Vietnam).

Thank you

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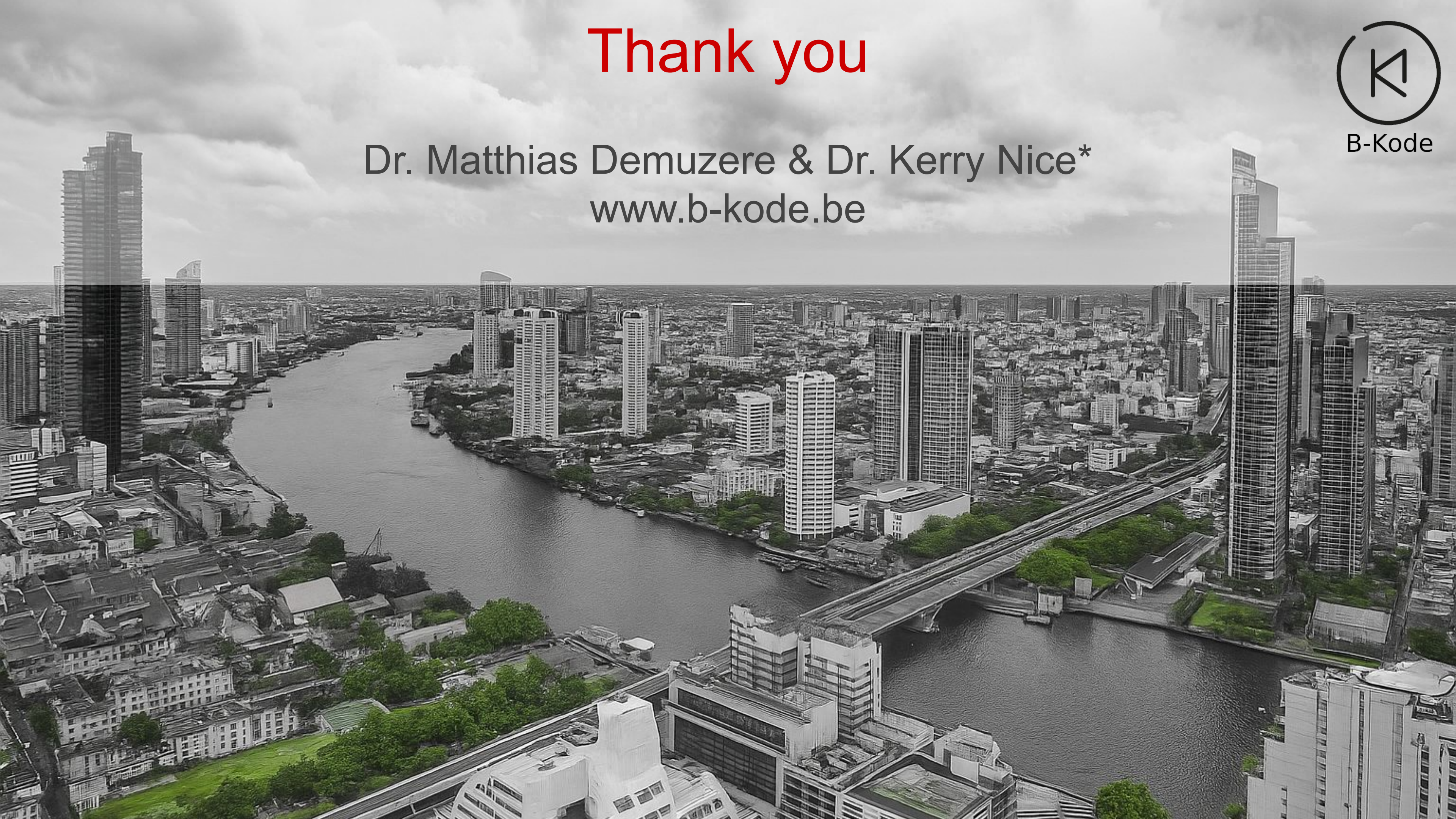
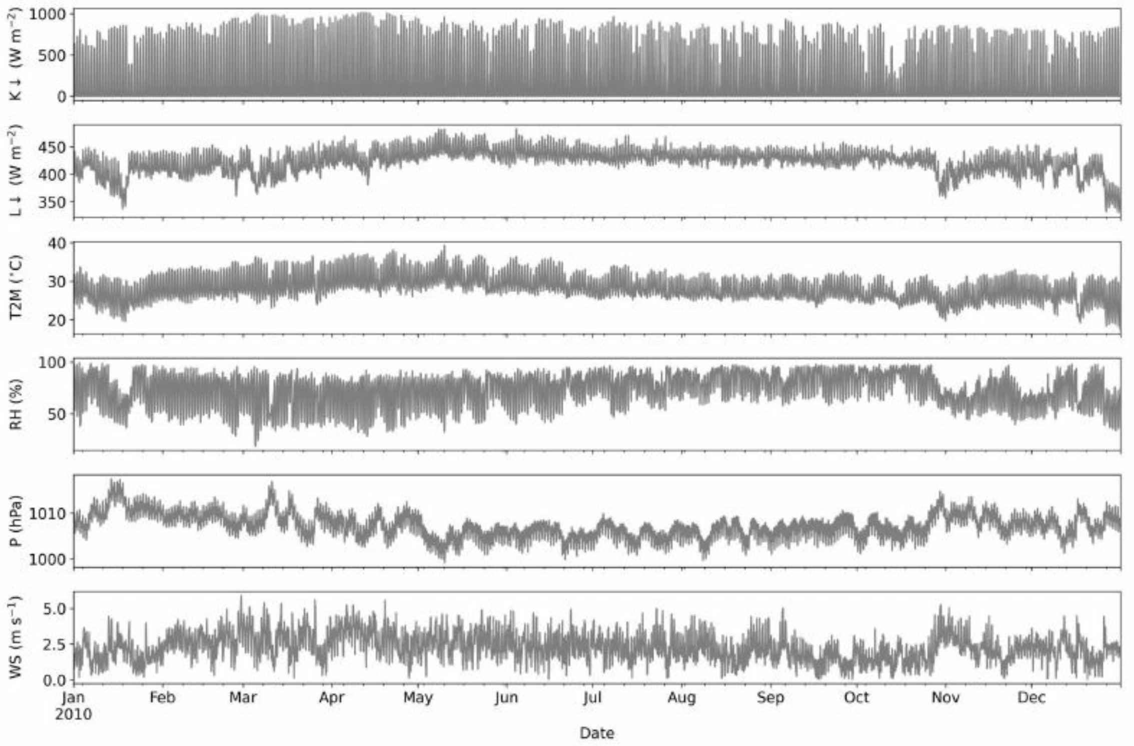


Supplementary information

Weather data to drive climate modelling

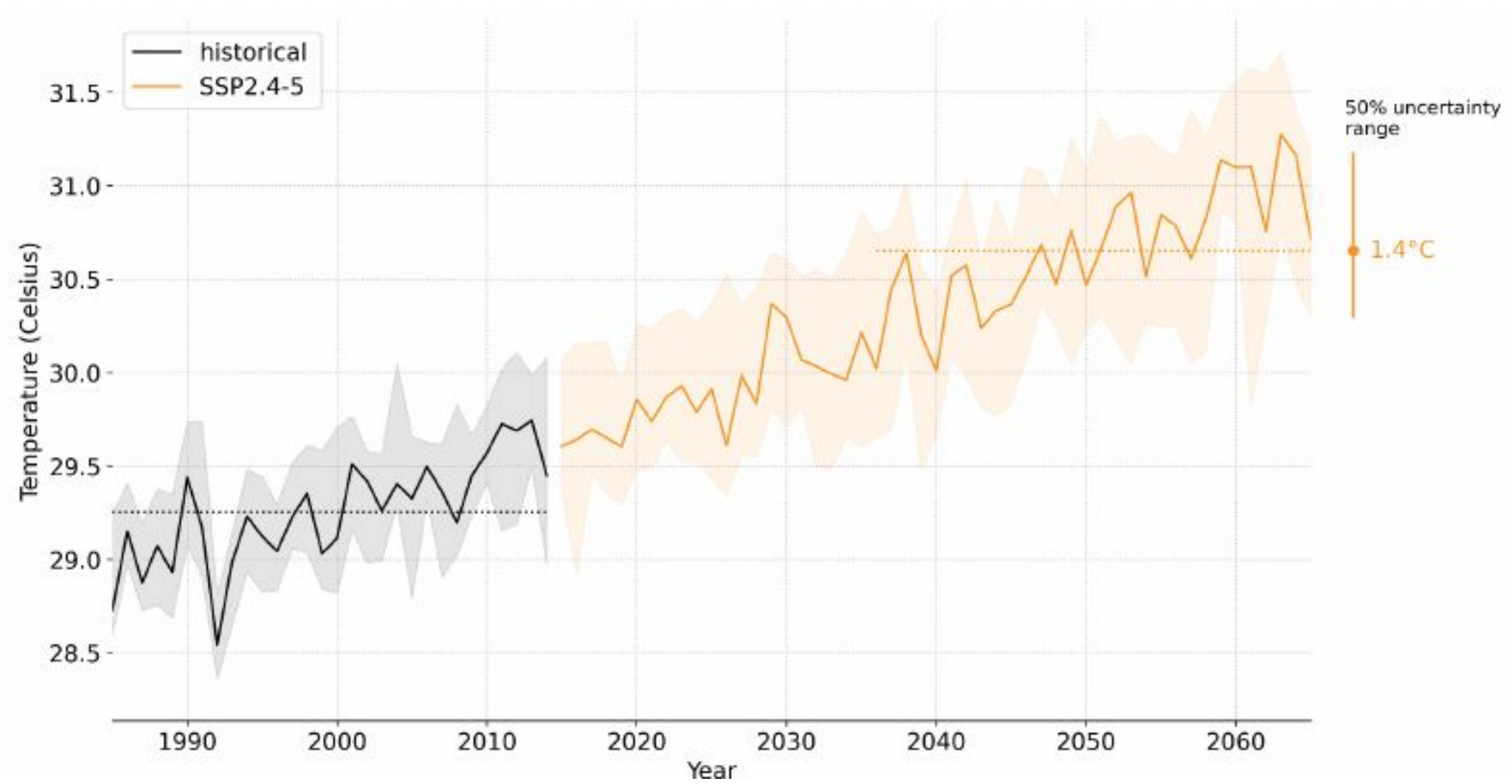
Figure 4: Historical hourly ERA5-Land forcing meteorology for Bangkok, showing only 2010 as an example.



Notes: Y-axis labels represent K↓ (incoming shortwave radiation), L↓ (incoming longwave radiation), T2M (2 metre air temperature), RH (relative humidity), P (sea level pressure), and WS (wind speed).
Source: B-Kode analysis based on ERA5-Land reanalysis

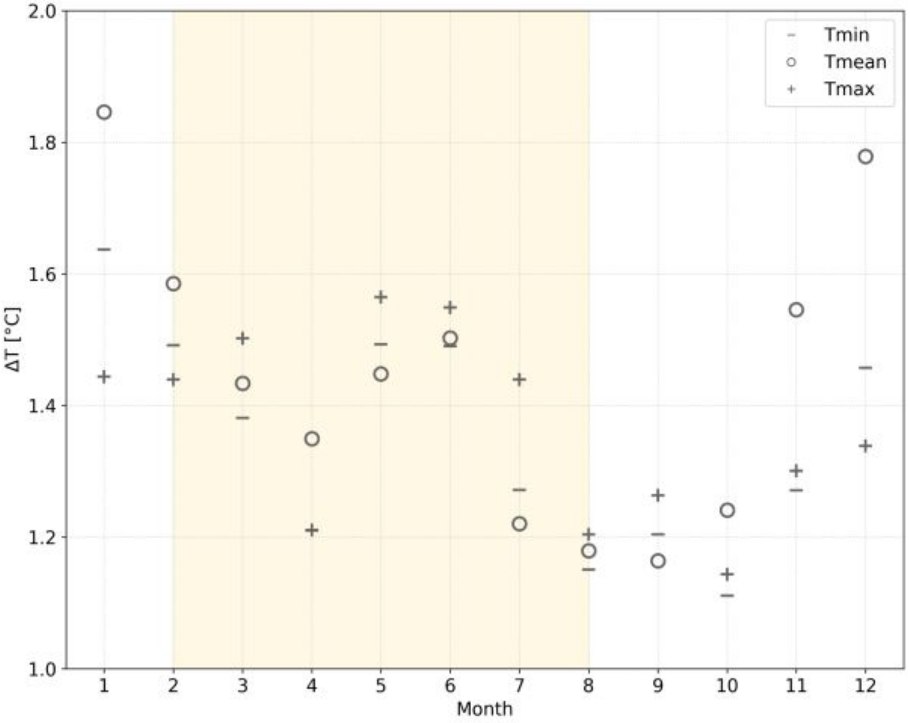
Incorporating climate change temperature increases

Figure 5: NEX-DCP30-CMIP6 average annual temperatures between 1985 and 2065.



Incorporating climate change temperature increases

Figure 6: Projected minimum (Tmin), mean (Tmean) and maximum (Tmax) monthly air temperature changes (ΔT, °C) for Bangkok, as the median over all available CMIP6 models, for SSP2-4.5 and target period 2050.

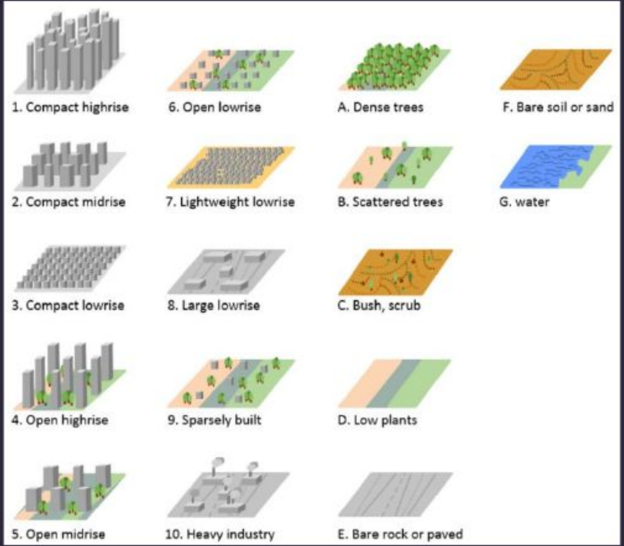


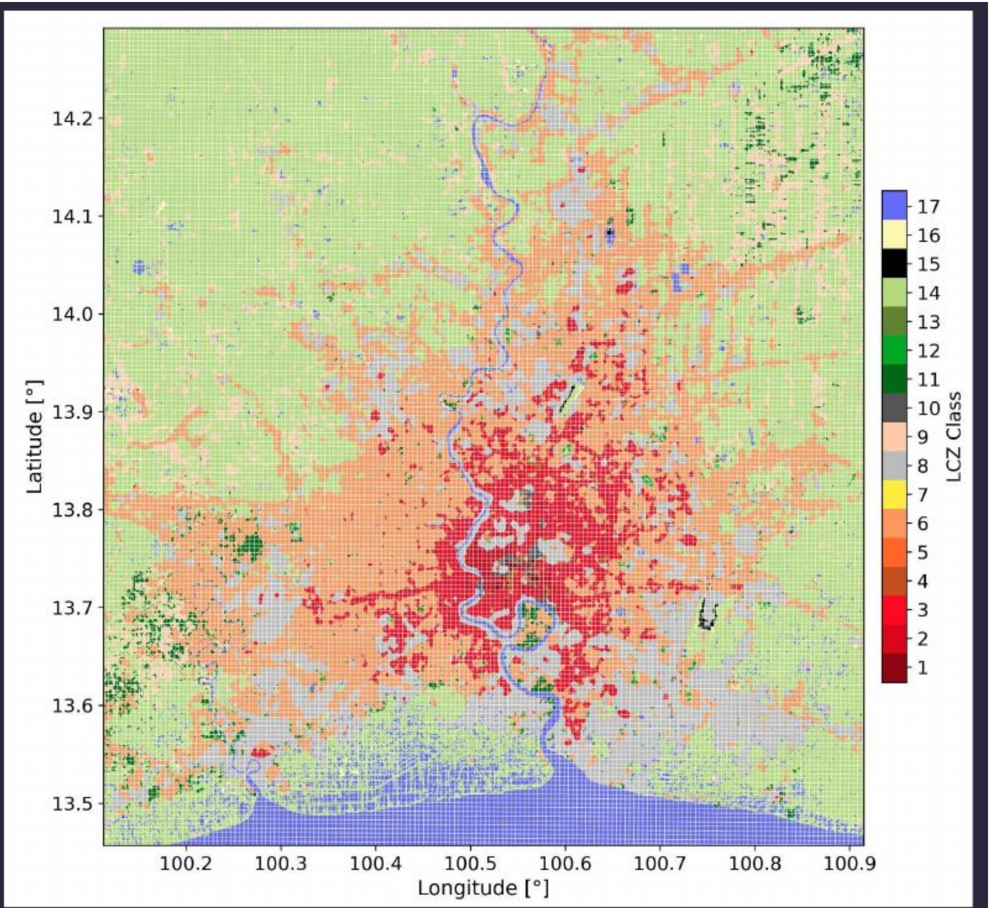
Notes: The yellow band indicates the February-July period of interest.
Source: B-Kode analysis based on ERA5-Land reanalysis and NEX-DCP30-CMIP6 data.

Modelling approach based on Local Climate Zones

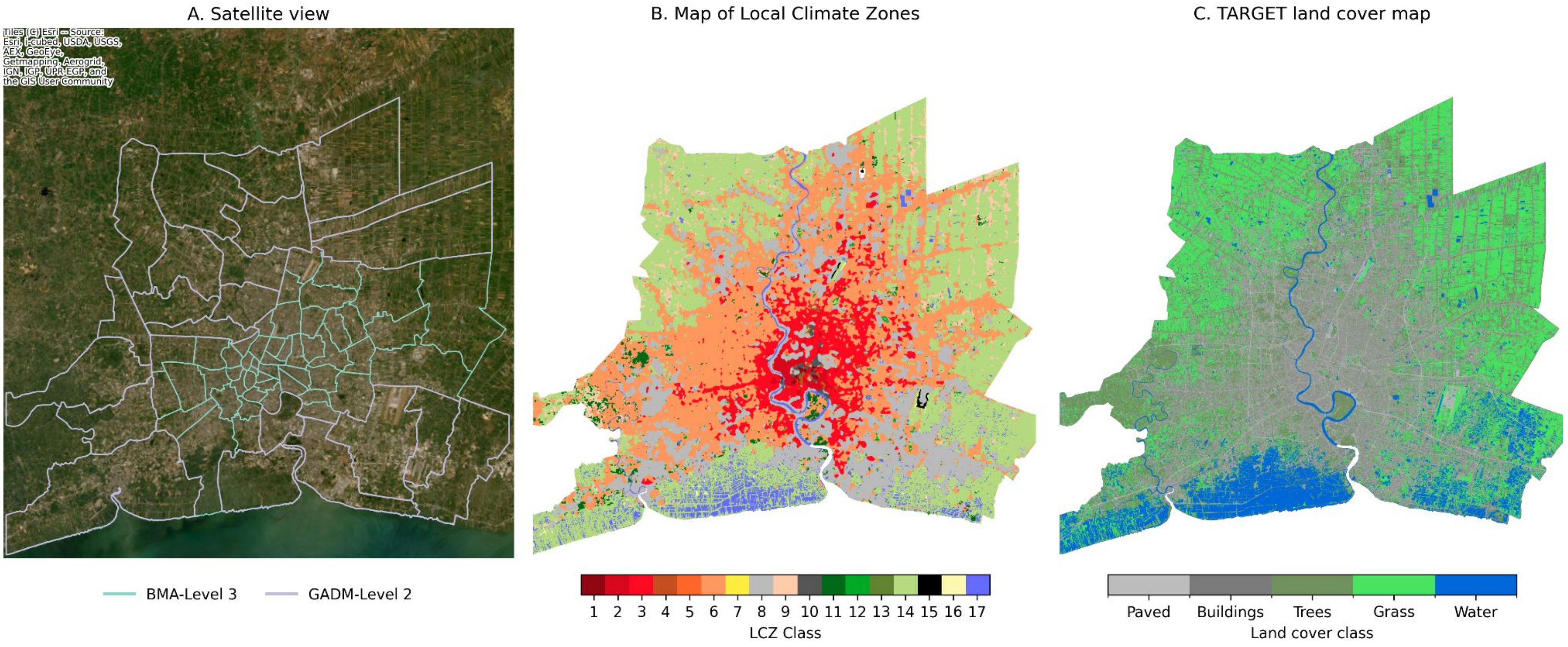
LCZ map for Bangkok, including the 500x500m² grid used for the TARGET simulations to describe urban form across the city

Note that LCZs 11-17 equal LCZs A-G





Modelling approach based on Local Climate Zones



Accounting for changes to urban form using NBS

Figure 7: Surface cover fractions for each available LCZ class, for business as usual (BAU), and high nature-based solution (NBS) scenarios.

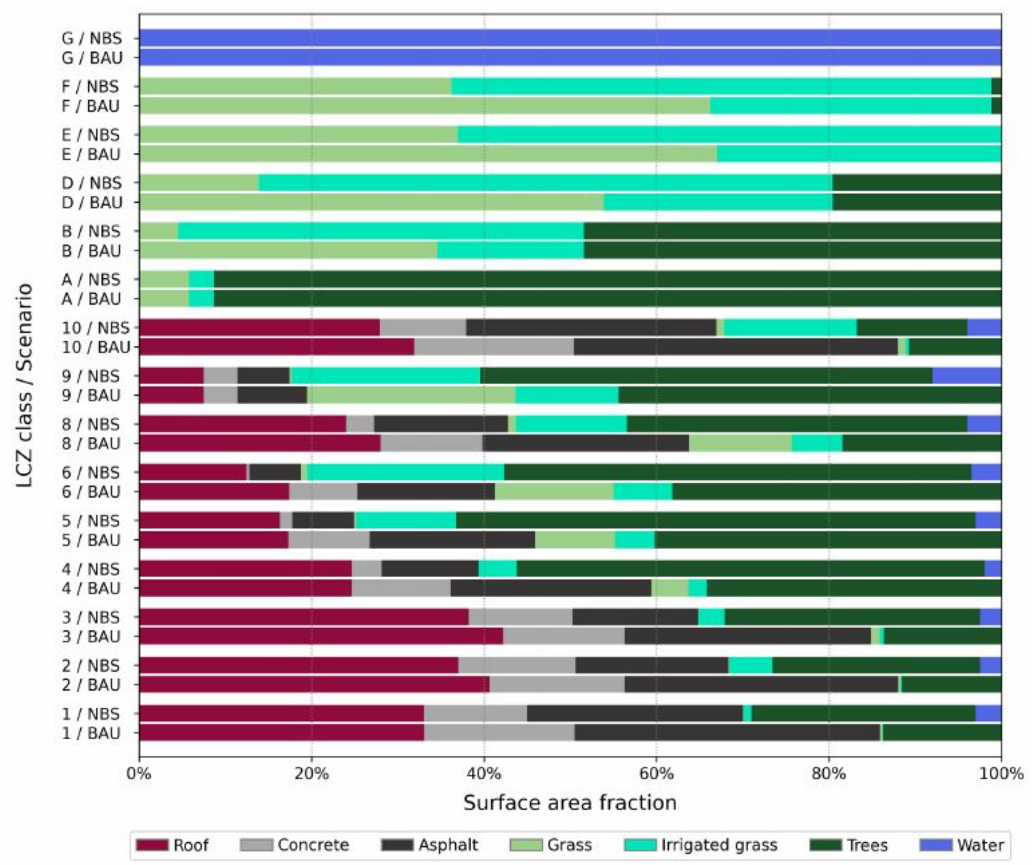
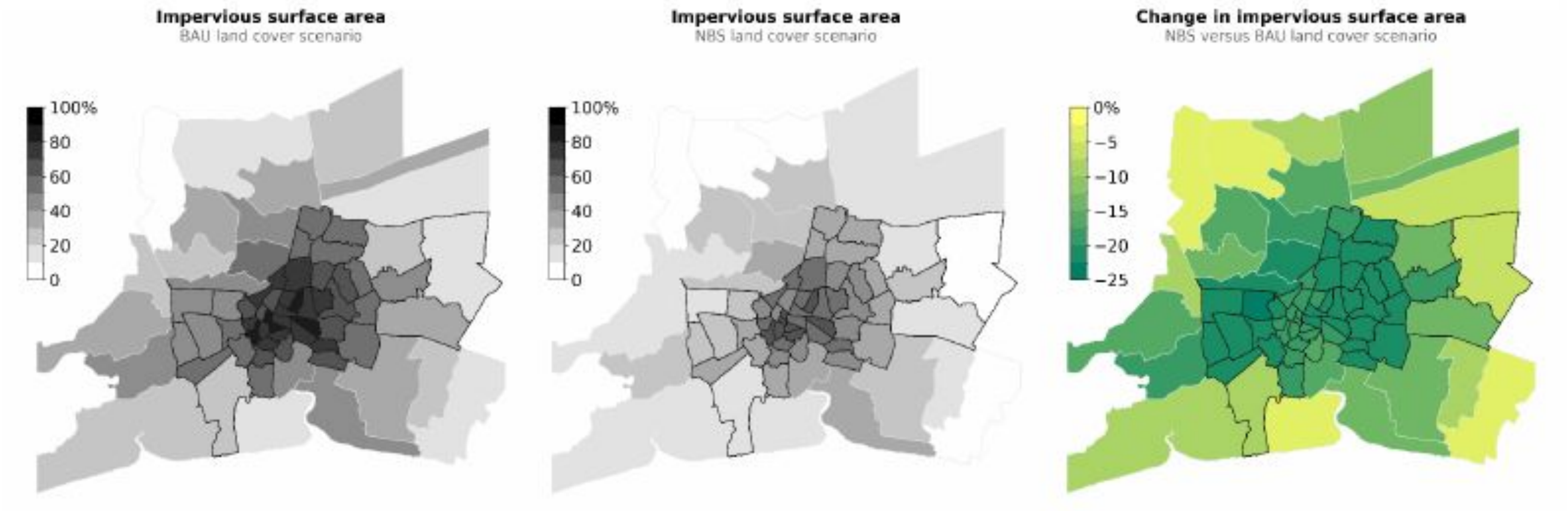


Table 1: Surface cover fractions for BAU scenarios followed by proposed tree canopy targets in the New South Wales Draft Urban Design Guidelines. Targets are given for both street trees and lots in various development categories.[24]

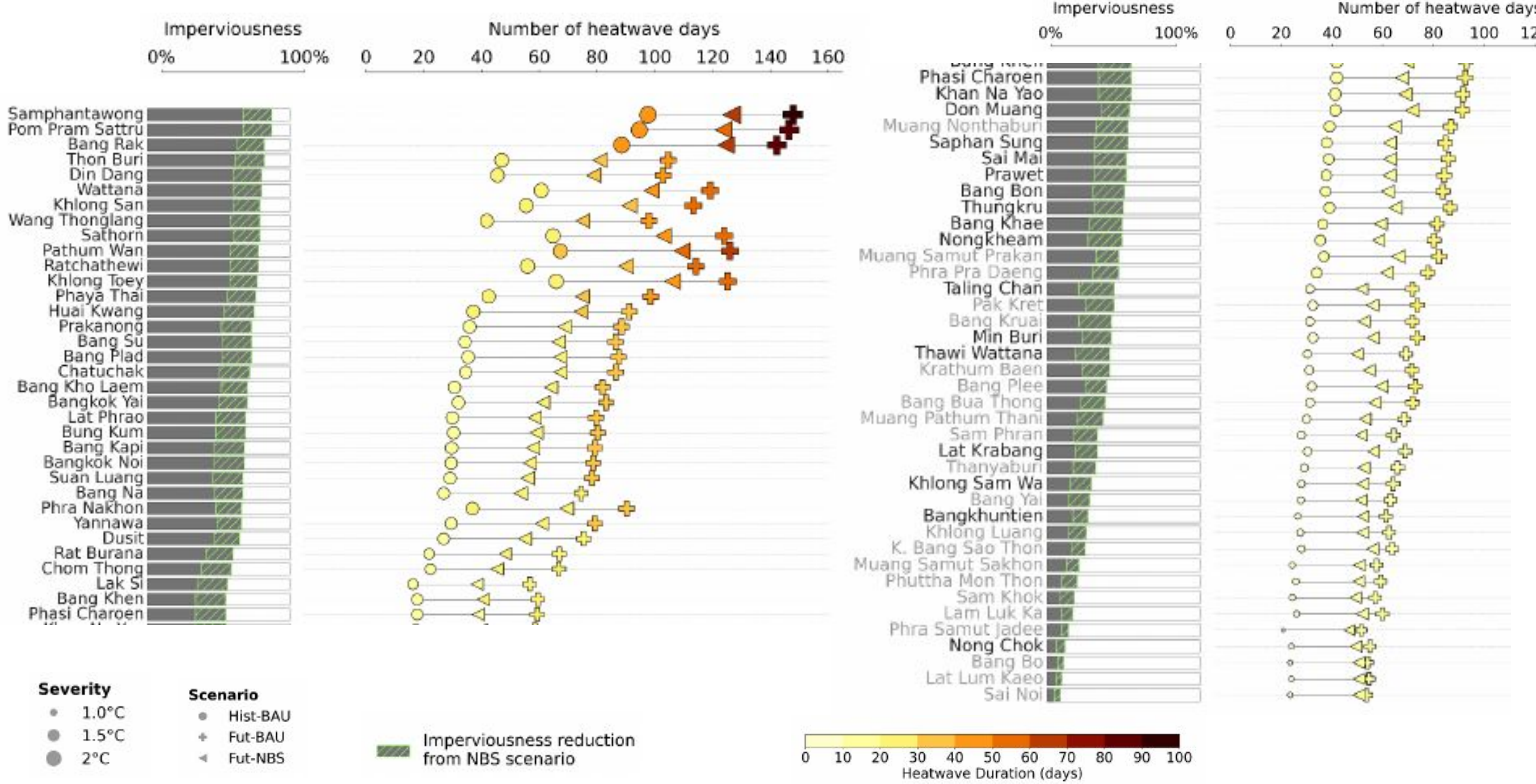
	BAU	Street tree canopy	Target[25]	Development category	Target	High NBS
LCZ 1	8%	Business parks	35%	Business parks (min deep soil target)	7%[26]	20%
LCZ 2	12%	Existing residential streets (12-20m reserve)	40%	Apartments (deep soil target)	15%[27]	30%
LCZ 3						
LCZ 4	10%			Attached dwellings (150-300m² lot size)	20%	30%
LCZ 5						
LCZ 6		19%		Detached dwellings (300-600m² lot size)	25%	35%
LCZ 8	4%	Existing industrial streets (20-25m reserve)	35%	Industrial	25%	25%
LCZ 9[28]	17%	Existing residential streets (12-20m reserve)	40%	Detached dwellings (>600m² lot size)	35%	25%
LCZ 10						
LCZ B	50%	Public open space	45%			50%
LCZ D	50%					

Reductions of impervious surfaces using NBS



Notes: The impervious surfaces are the sum of TARGET's roof and paved (concrete and asphalt) surface fractions. The pervious surfaces are the sum of the trees, (irrigated) grass, and water fractions. LCZ-based changes of each of these surfaces between BAU and NBS are shown in Figure 7.
Source: B-Kode analysis.

Overall impacts of NBS on heatwave trends in Bangkok in the past and future



Microclimate Heat modelling: Application case study area of Bangkok

Urban Heat Resilience:

Bridging Science, Policy, and Sustainable Design

Funded by:

Dr. Matthias Demuzere
Dr. Kerry Nice

Australian Government
Department of Foreign Affairs and Trade

SUMERNET

SEI

B-Kode

B-Kode's project involvement

Our Role

Urban Heat Modelling

- Modelling of canopy-layer air temperatures and thermal comfort with TARGET, that includes the effect of blue and green infrastructure, and is based on the concept of Local Climate Zones
- Initially to applied to assess present-day neighbourhood-scale urban climate characteristics over Bangkok

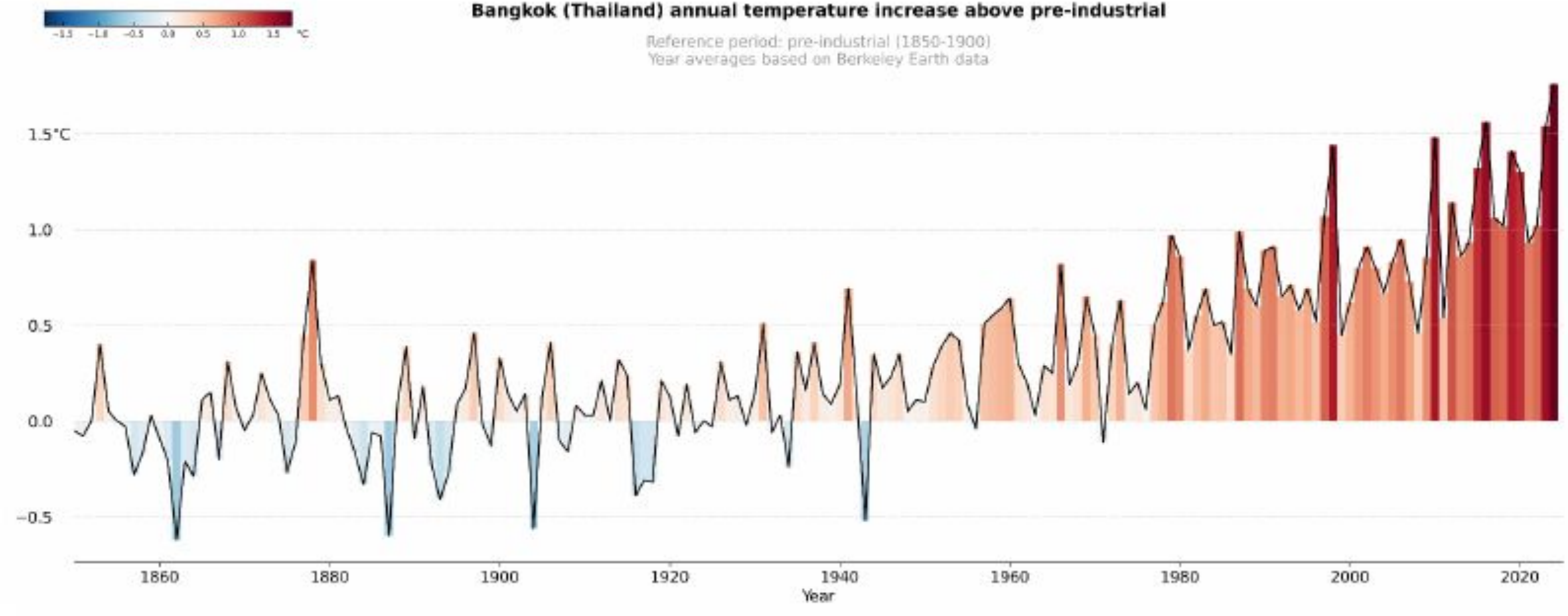
Scenario Analysis

- Assess **impact of future climate** (middle of the road future climate change scenario representative for 2050), combined with **urban development scenarios** (business-as-usual and nature-based solution interventions)

Impact Modelling

Rising temperatures in Bangkok up to the present

Figure 2: Annual temperature increase above the pre-industrial period for Bangkok



Source: B-Kode analysis based on Berkeley Earth data.

Project methodology

1 Methodology

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Present day and future urban cooling enabled by integrated water management

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Inputs

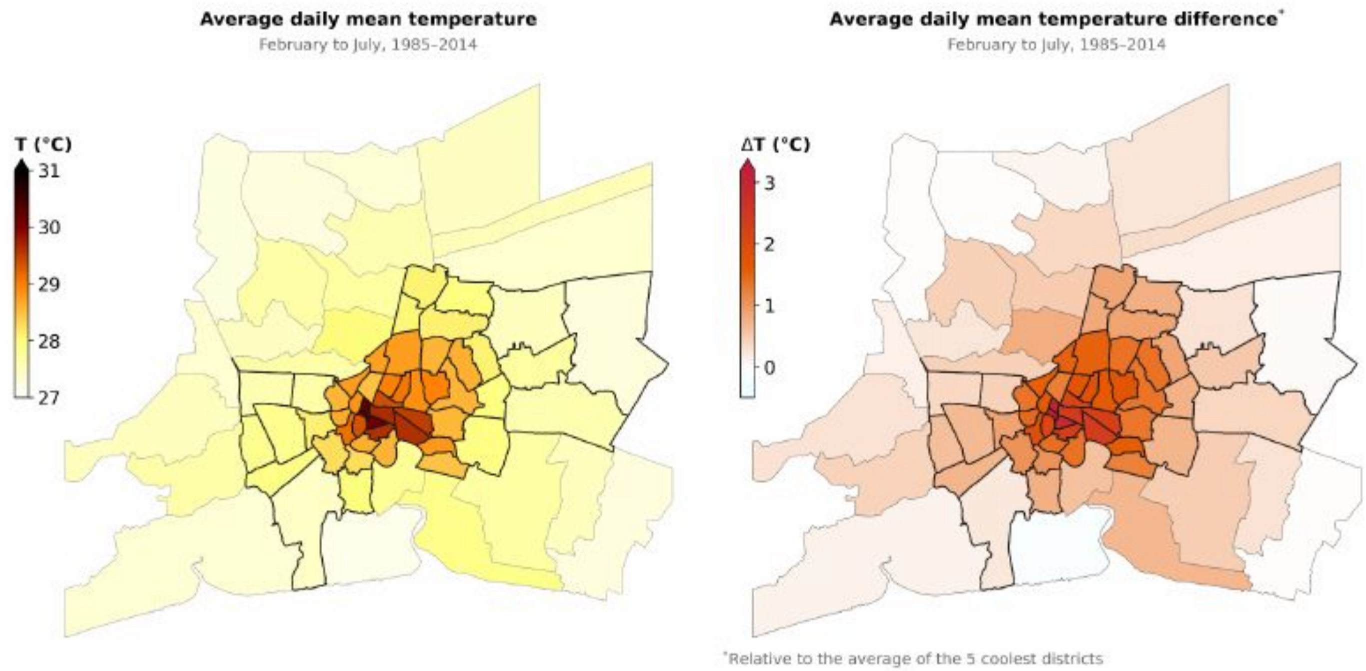
- Present-day and future atmospheric forcing based on reanalyses and CMIP6 climate projections
- Urban development based on Local Climate Zones

Outputs

- Decadal (2011-2020 and 2041-2060) hourly time series of modelled 2m air temperature and urban thermal comfort for a 500x500m^2 grid covering the wider Bangkok area

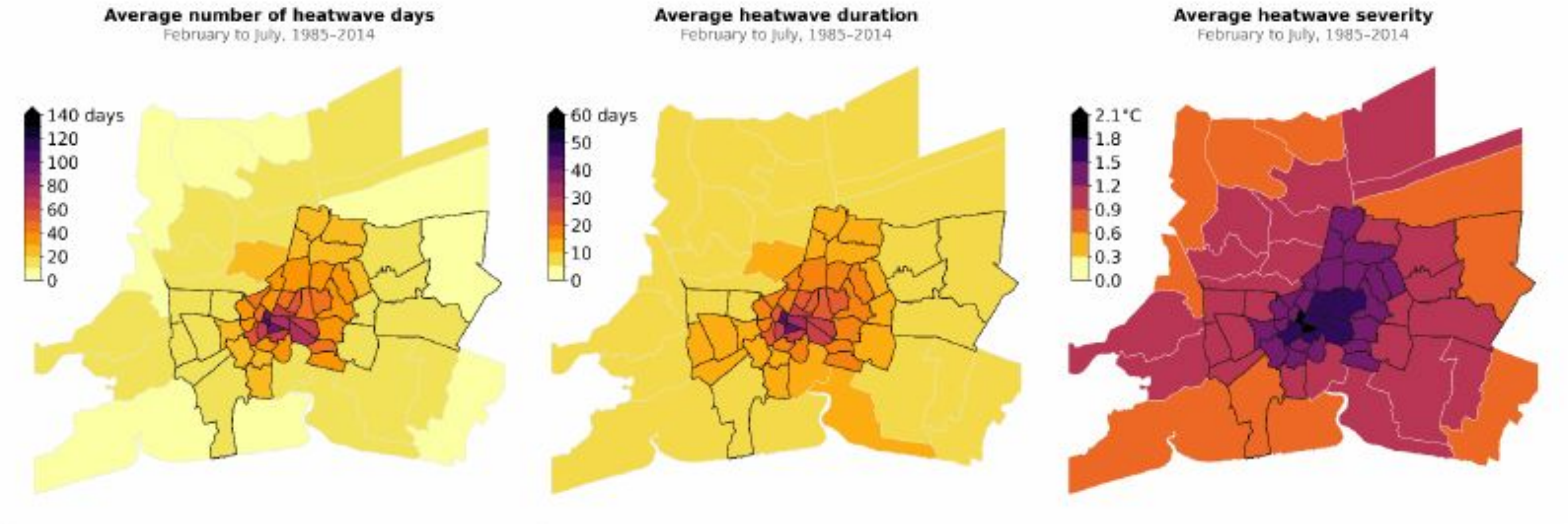
Modelling results across Bangkok in present day

Figure 8: Central districts within the Bangkok Metropolitan Area exhibit significantly higher temperatures compared to their surrounding less urbanized districts.



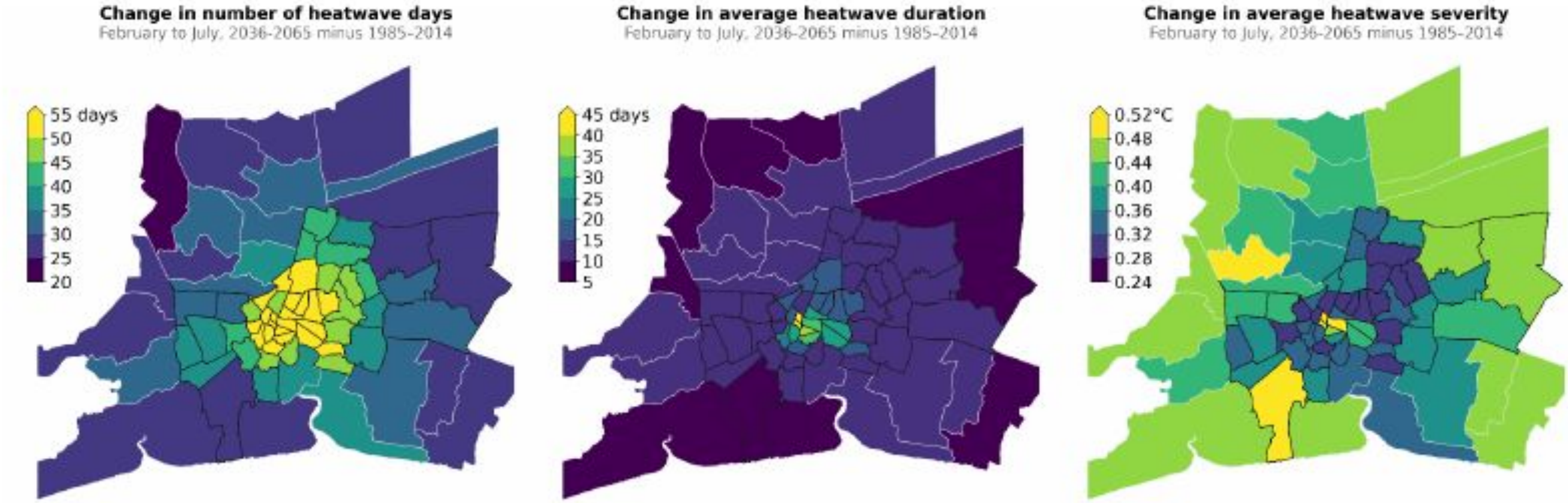
Notes: The five coolest districts are white-colored in the right panel, and are Sai Noi (THA.36.6_1), Lat Lum Kaeo (THA.37.3_1), Phra Samut Jadee (THA.57.6_1), Bang Bo (THA.57.1_1), Nong Chok (THA.3.28_1). Values in brackets refer to the GID_2 id from the gadm database.
Source: B-Kode analysis based on TARGET simulations.

Present day heatwave characteristics in Bangkok



Source: B-Kode analysis based on TARGET simulations.

Changes to heatwave characteristics by 2065



Notes: Changes are calculated as the difference between the heatwave characteristics averaged for 2036-2065 SSP2-4.5 and the historical period 1985-2014.
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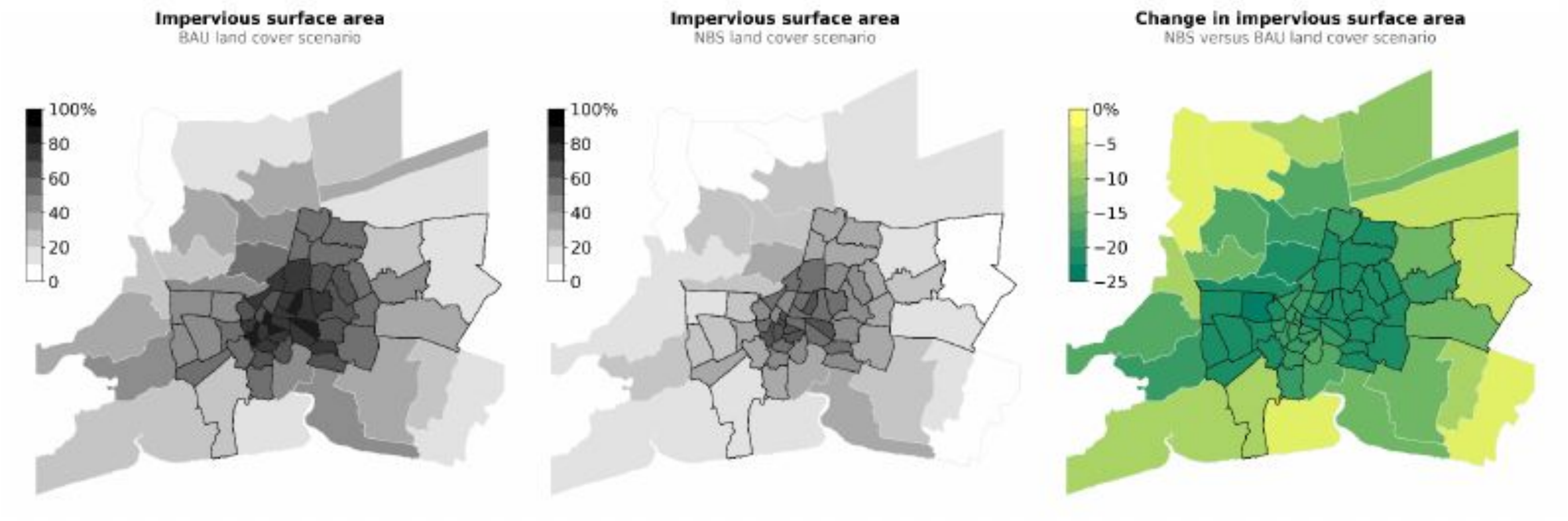
Reductions of impervious surfaces using NBS



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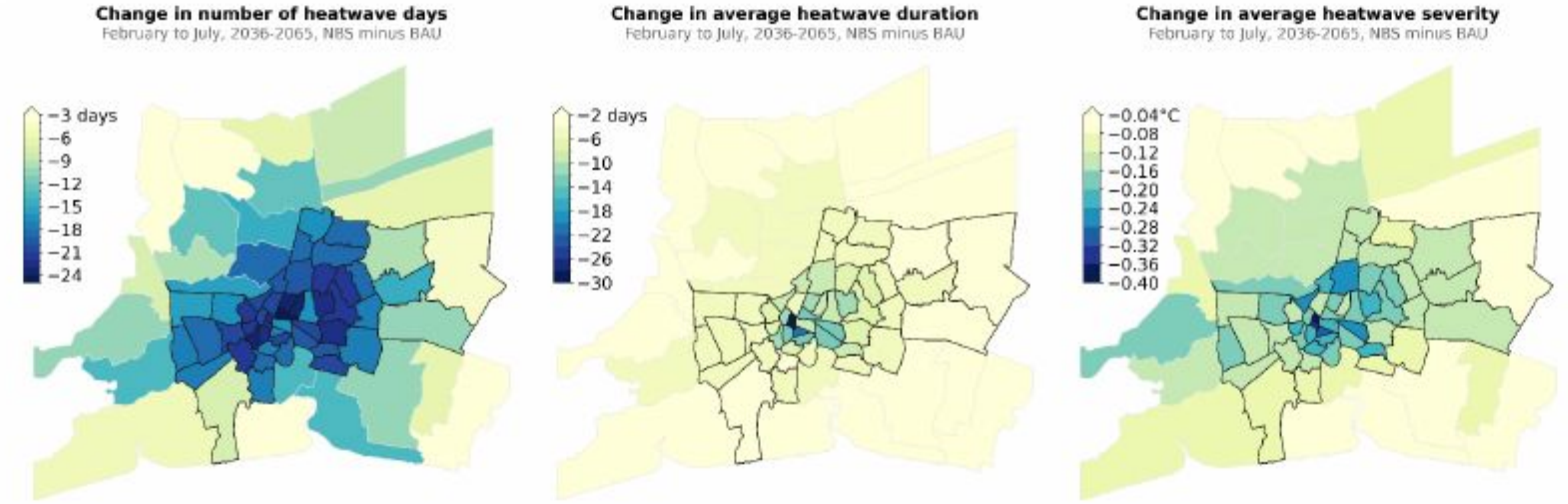
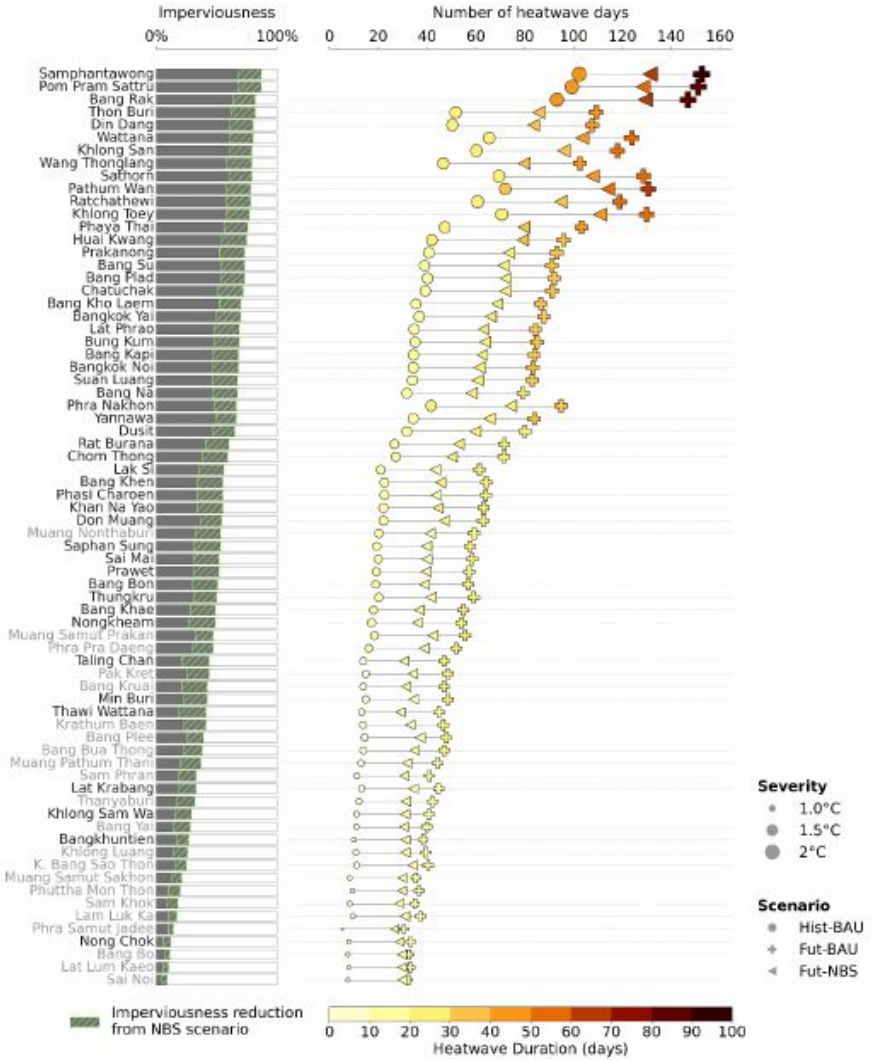
Heatwave dampening enabled by NBS



Source: B-Kode analysis based on TARGET simulations.

Overall impacts of NBS on heatwave trends in Bangkok in the past and future



Overall findings

NBS interventions lead to:

- A marked reduction in impervious surface area, with central and western districts seeing the most significant shifts.
- A clear cooling benefit, reducing the number of heatwave days by up to 24 days in hotspots.
- Shorter, less persistent heatwave events, with average durations dropping by over 30 days in some districts.
- Slight but important reductions in heatwave severity, particularly in densely built areas where thermal extremes are most acute.

NBS benefits not necessarily uniformly distributed but spatially consistent with areas of greatest intervention.

Greening strategies can partially but not completely offset future projected warming. Adaptation must also include measures using NBS but also additional measures are needed such as deploying heat alert systems, cooling centres, hydration points and a greater emphasis on embedding heat resilience in urban design, planning and policy.