Remote Sensing Assessment of Land Surface Temperature and Vegetation Cooling in Vilnius, Kaunas and Klaipėda

Adas PRANCKEVIČIUS[1], Aušra ZIGMONTIENĖ[1], Ruta VANAGA[2]

[1]Vilnius Gediminas Technical University, Department of Environmental Protection and Water Engineering

[2]Riga Technical University, Institute of Energy Systems and Environment

Contact information:

Saulėtekio al. 11, LT10223, Vilnius, Lithuania

+37063930378

adas.pranckevicius@stud.vilniustech.lt

Tree vegetation is a major factor in shaping surface thermal patterns and cooling across urban areas

- Vilnius is the most vegetation dominated city, with trees covering 57.3% of municipal area, while Kaunas has the biggest share of artificial surfaces (33.3%).
- In 2019-2023, average land surface temperature during warm seasons was highest in Kaunas (28.3 °C), while in Vilnius and Klaipėda it was 1.5 °C and 2 °C lower, mainly due to vegetation and water related cooling, respectively.
- Industrial and commercial areas with large buildings formed the main thermal hotspots in cities, surface temperature in those hotspots reached around 40–43 °C under typical conditions and up to 54 °C during heatwaves.
- On a city level, tree cover related cooling was strongest in Vilnius – around 2 °C, the cooling effect in Kaunas and Klaipėda was around 1 °C weaker.
- Scenario based analysis showed that increasing or decreasing tree cover density in a neighbourhood by about 2–6 percentage points can alter the local cooling by 0.1–0.6 °C

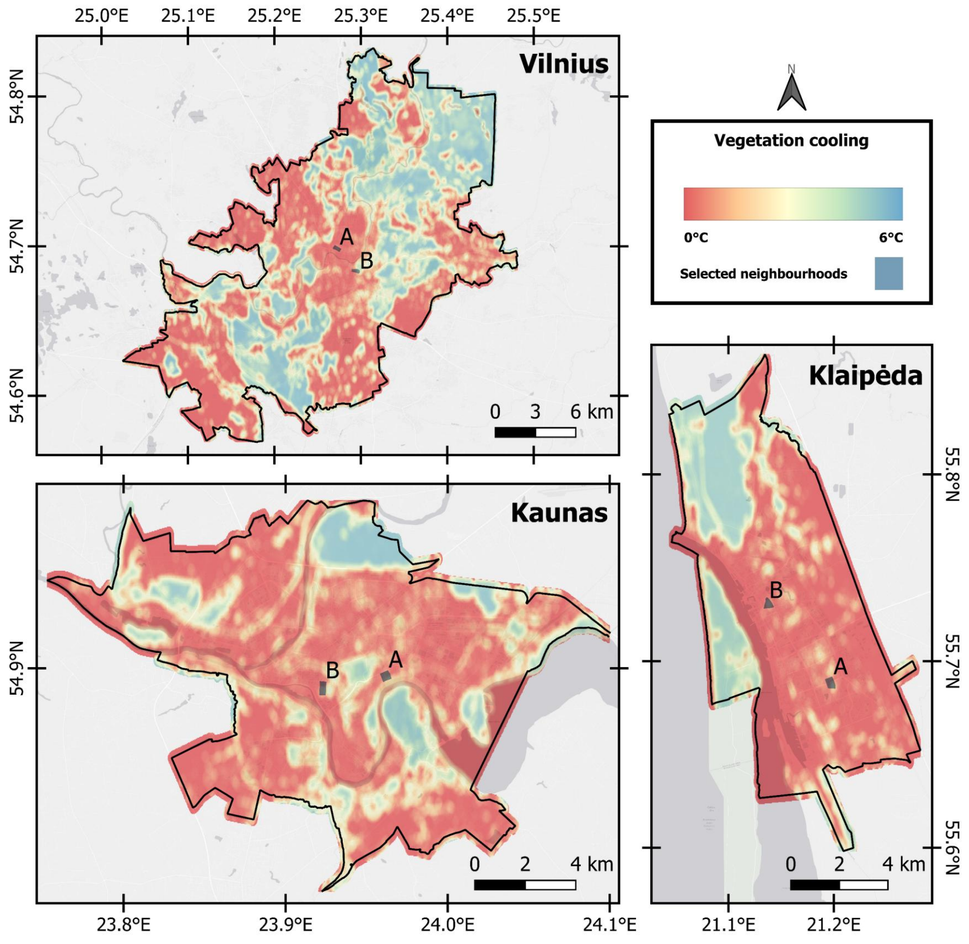

Fig. 1. Spatial distribution of modelled tree vegetation cooling under typical warm season thermal conditions

Introduction

Urbanisation in many parts of Europe is still ongoing, and as cities continue to expand, natural surfaces are increasingly being replaced by artificial materials, which absorb and retain heat more effectively than vegetation. This intensifies surface heating, increases thermal stress and creates challenges for public health, energy demand and climate adaptation. European Green Deal as well as EU and national climate adaptation strategies emphasize the need for methods to evaluate what impact certain decisions will have. The aim of this study is to assess surface thermal patterns and vegetation related cooling in Vilnius, Kaunas and Klaipėda municipalities using remote sensing data and to evaluate how changes in tree cover density impact the local cooling effect in different city neighbourhoods.

Methods

Land surface temperature was derived from Landsat 8/9 data and tree cover density from Copernicus High Resolution Layer Tree Cover Density product. Typical thermal conditions were calculated as the average of all 2019–2023 observations during warm seasons (May-September), heatwave conditions were derived from single scenes. Tree cover related cooling was estimated from statistical relationship between land surface temperature and tree cover density in each city. Scenario based changes to tree cover density were then modelled in selected neighbourhoods in each city to assess the impact of the changes on local cooling.

Conclusions

Results confirmed that tree cover area and density is major factor in shaping surface thermal patterns and reducing surface heating. Scenario based analysis demonstrated that increase of tree cover density in targeted areas improves local cooling, especially in densely built-up areas. For example, increasing average tree cover density from 10% to 14% in the neighbourhood area of site A in Kaunas, improves local cooling by 0.22–0.25 °C depending on thermal conditions. Findings from this study show that an approach using remote sensing could support climate adaptation and urban planning by identifying areas where increasing tree cover area and density is feasible and could provide noticeable local cooling effect.

Results

Vilnius showed strongest and most extensive cooling pattern, Kaunas had a more fragmented but heat sensitive response, due to being a smaller and more compactly structured city (comparing municipal area) and Klaipėda had the weakest relationship between land surface temperature and tree cover density, mainly due to the influence of coastal environment.

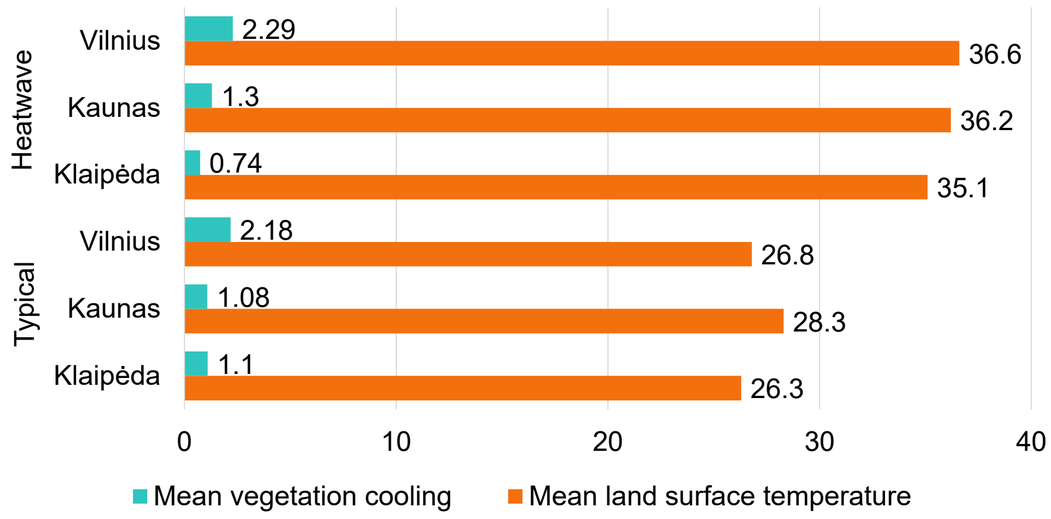

Fig. 2. Mean land surface temperature and vegetation cooling under different thermal conditions

At a neighbourhood scale, slight changes in tree cover density produced modest but still locally significant cooling changes, even though the modified sites represented only around 7% of each neighbourhood area.

Table 1. Mean cooling response to tree cover density change in selected neighbourhood sites under different thermal conditions

City	Site	Area, km²	Tree cover density change, pp (percentage points)	Thermal conditions	Cooling baseline, °C	Cooling scenario, °C	Cooling change, °C
Vilnius	A	0.16	2.5	Baseline	0.37	0.51	0.14
				Heatwave	0.39	0.56	0.17
	B	0.14	-2.0	Baseline	1.14	1.02	-0.12
				Heatwave	1.19	1.04	-0.15
Kaunas	A	0.13	4.0	Baseline	0.54	0.76	0.22
				Heatwave	0.65	0.90	0.25
	B	0.13	-6.0	Baseline	0.65	0.32	-0.32
				Heatwave	0.78	0.21	-0.56
Klaipėda	A	0.14	3.6	Baseline	0.70	0.87	0.17
				Heatwave	0.45	0.56	0.11
	B	0.12	-3.7	Baseline	0.63	0.46	-0.17
				Heatwave	0.42	0.30	-0.12