2.10.2. Number of combined tropical nights and hot days

Project Name: UNaLab (Grant Agreement no. 730052)

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Heatwave incidence expressed as the number of combined tropical nights (>20°C) and hot days (>35°C) per annum	**Climate Resilience** **Natural and Climate Hazards**
Description and justification	Heatwave is a period of prolonged abnormally high surface temperatures relative to those normally expected. Heatwaves can be characterized by low humidity, which may exacerbate drought, or high humidity, which may exacerbate the health effects of heat-related stress such as heat exhaustion, dehydration and heatstroke. Heatwaves in Europe are associated with significant morbidity and mortality. Furthermore, climate change is expected to increase average summer temperatures and the frequency and intensity of hot days (Russo et al., 2014). EEA models indicate an increase in combined tropical nights (minimum temperature >20°C) and hot days (maximum temperature >35°C) under present and future climate conditions[4]. In cities and urban areas, the UHI tends to exacerbate heatwave episodes.
Definition	Number of combined tropical nights (minimum temperature >20°C) and hot days (maximum temperature >35°C)
Strengths and weaknesses	+ Easy and straightforward assessment - Requires substantial amount of external data for modelling
Measurement procedure and tool	This indicator is assessed through continuous monitoring of temperature, and/or estimated by applying meteorological models such as the Weather Research and Forecasting WRF model (NCAR & UCAR, n.d.; NOAA, n.d.) "Tropical nights" are defined as days when the daily minimum temperature is >20°C. The number of tropical nights is equal to the number of days annually when the daily minimum temperature is >20°C (ETCCDI;

[4] https://www.eea.europa.eu/data-and-maps/figures/increase-in-the-number-of

	http://etccdi.pacificclimate.org/list_27_indices.shtml). For the purposes of this indicator, “hot days” are defined as days when the daily maximum temperature is >35°C.
Scale of measurement	Neighbourhood to regional scale
Data source	
Required data	For modelling: initial and boundary conditions, topography, land use and urban parameters (building height, width, number of road lanes) (Emmons et al., 2010; Pineda, Jorba, Jorge & Baldasano, 2004). These data can be obtained through national statistics, municipal departments, Corine Land Cover, and a mapping application such as OpenStreetMap. For direct measurements: hourly mean values of ambient air temperature
Data input type	Quantitative
Data collection frequency	Annually, and before and after NBS implementation
Level of expertise required	Low – for continuous temperature monitoring High – for applying meteorological models
Synergies with other indicators	Assessed from *Mean or peak daytime temperature* indicator and connected with *Urban Heat Island* indicator
Connection with SDGs	SDG 3 Good health and well-being, SDG 11 Sustainable cities and communities, SDG 13 Climate action
Opportunities for participatory data collection	Participatory data collection is feasible through sample collection, e.g., air temperature measurements if these are not automated
Additional information	
References	Emmons, L.K., Walters, S., Hess, P.G., Lamarque, J.-F-, Pfister, G.G., Fillmore, D. … Kloster, S. (2010). Description and evaluation of the Model for Ozone and Related chemical Tracers, version 4 (MOZART-4). *Geoscientific Model Development*, *3*, 43-67. National Center for Atmospheric Research (NCAR) & University Corporation for Atmospheric Research (UCAR). (n.d.). Weather Research and Forecasting (WRF) Model Users' Page. Retrieved from http://www2.mmm.ucar.edu/wrf/users/ National Oceanic and Atmospheric Administration (NOAA). (n.d.). Weather Research and Forecasting model coupled to Chemistry (WRF-Chem). Retrieved from https://ruc.noaa.gov/wrf/wrf-chem/ Pineda, N., Jorba, O., Jorge, J. & Baldasano, J.M. (2004). Using NOAA AVHRR and SPOT VGT data to estimate surface parameters: application to a mesoscale meteorological

	model. *International Journal of Remote Sensing*, *25*(1), 129–143. Russo, S., Dosio, A., Graversen, R., Sillmann, J., Carrao, H., Dunbar, M.B. …Vogt, J.V. (2014). Magnitude of extreme heat waves in present climate and their projection in a warming world. Journal of Geophysical Research: Atmospheres, 119(22), 12500–12512. Weather Research and Forecasting Model (WRF): https://www.mmm.ucar.edu/weather-research-and-forecasting-model

2.10.3 Thermal Storage Score

Project Name: Nature4Cities (Grant agreement: No. 730468)

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Thermal Storage Score	Climate Resilience
Description and justification	The TSS (Thermal Storage Score) is one out of five Key Performance Scores of the GREENPASS® system. It expresses the stored energy within materials in an urban area. A high value indicates elevated probability of overheating and urban heat island risk. The indicator is relevant for the urban heat island mitigation and influenced by the application of NBS.
Definition	The TSS (Thermal Storage Score) describes the stored energy in urban materials on a standardized heat day.
Strengths and weaknesses	+ worldwide standardized key performance score regarding thermal storage capacity and energy + easy for communication and decision-making + useful for design optimization - needs simulation
Measurement procedure and tool	- modelling, simulation tools and GREENPASS® analysis and calculation - numerical value in J
Scale of measurement	Object and neighbourhood scale
Data source	
Required data	- air temperature (Ta) - incoming shortwave radiation (direct & diffuse) - physical parameters of surfaces and materials