2.17 Rate of evapotranspiration

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Rate of evapotranspiration	**Climate Resilience Water Management**
Description and justification	Evapotranspiration (ET) is a combination of two separate processes whereby water is lost from the soil surface by evaporation and from vegetation by transpiration. Water evaporates from surfaces when sufficient heat is supplied for liquid water to transition to water vapour. During transpiration, plant tissues vaporise water, which is then released to the atmosphere through stomatal openings on the plant leaf. Nearly all water taken up by plants is released to the atmosphere through transpiration. In addition to the non-uniformity of urban vegetation, shading of urban vegetation by landscape trees and structures and edge effects due to the relatively small scale of urban green space in comparison to commercial crop fields can significantly influence ET (Snyder, Pedras, Montazar, Henry, & Ackley, 2015).
Definition	Measured or modelled evapotranspiration (typically expressed in mm per unit time, e.g., mm/day)
Strengths and weaknesses	+ The reference evapotranspiration, ET_o, provides a standard to which: (a) evapotranspiration at different periods of the year or in other regions can be compared; (b) evapotranspiration of other crops can be related (Allen, Pereira, Raes, & Smith, 1998). + Standard, widely-applied technique - Challenging and expensive to measure directly - Requires high level of expertise to apply
Measurement procedure and tool	Evapotranspiration is measured involving specific devices and accurate measurements of various physical parameters or the soil water balance in lysimeters. In practice, ET is commonly calculated using meteorological data. Commercially-available ET monitoring stations are generally meteorological stations that calculate potential ET using monitored temperature, relative humidity, wind speed and direction, solar radiation, and precipitation data. The Penman-Monteith equation is the FAO-recommended

	standard technique for calculation of reference evapotranspiration, ETo from crops (Allen, Pereira, Raes, & Smith, 1998). The FAO Penman-Monteith method to estimate ETo is presented in Equation 1: $$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$ Where ETo is reference evapotranspiration [mm day-1], Rn is net radiation at the crop surface [MJ m-2 day-1], G is soil heat flux density [MJ m-2 day-1] ,T is mean daily air temperature at 2 m height [°C], u2 is wind speed at 2 m height [m s-1], es is saturation vapour pressure [kPa], ea is actual vapour pressure [kPa], es - ea is saturation vapour pressure deficit [kPa], D is slope vapour pressure curve [kPa °C-1], and g is psychrometric constant [kPa °C-1]. Using the Penman-Monteith equation, ET from plant surfaces under standard conditions is determined using an experimentally-determined coefficient (kc) to relate the ET for a specific crop species, ETc, to ETo. Thus, for a given crop species: $$ET_c = k_c \times ET_0$$ For urban landscapes, the landscape coefficient method (LCM), which uses a different set of coefficients rather than kc to estimate ET, may be more appropriate (Costello, Matheny, Clark, & Jones, 2000): $$ET = k_L \times ET = k_d \times k_s \times k_{mc} \times ET_0$$ where kL is a landscape coefficient defined as a product of kd, a planting density factor, kS, a species-specific factor, and kmc, a microclimate factor. The modifications of the Penman-Monteith equation for plant-specific conditions can be found in the publications by, e.g., Litvak and Pataki (2016) and Litvak, Manago, Hogue, and Pataki (2016).
Scale of measurement	Plot scale, can be extrapolated using land cover data
Data source	
Required data	Radiation, air temperature, wind speed, vapour pressure, soil heat flux density
Data input type	Quantitative
Data collection frequency	Annually, and before and after NBS implementation

Level of expertise required	High – requires ability to apply the Penman-Monteith equation and evaluate the results
Synergies with other indicators	Related to *Daily temperature range, Land surface temperature* and *Surface reflectance - Albedo* indicators; a possible consequence of *Green space management* and *Place regeneration* indicator groups
Connection with SDGs	SDG 11 Sustainable cities and communities
Opportunities for participatory data collection	No opportunities identified
Additional information	
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