Supplementary Information

1. Water Retention

Water retention (WR) is calculated by combining water yield with runoff coefficient, terrain index, and soil saturated hydraulic conductivity. The calculation formula are as follows :

$$\mathrm{W}R = \min(1, \frac{249}{Velocity}) \times \min(1, \frac{0.9 \times TI}{3}) \times \min(1, \frac{Ksat}{300}) \times Y_x$$

$$Y_x = (1 - \frac{AET_x}{P_x}) \times P_x$$

Where WR is the amount of water retention(mm); Y_x is the water yield of grid x (mm); AET_x is the annual actual evapotranspiration value for grid x(mm); P_x refers to annual precipitation for grid x (mm); the parameters such as evapotranspiration coefficient and maximum root depth were set by reference[1-3] (Table S1). Velocity set by USDA-NRCS National Engineering Manual (dimensionless); TI is the terrain index, which is calculated by the multi-flow method[4] (dimensionless); ksat is the soil water retention rate (mm), which is calculated based on Neuro Theta software.

Table S1 Biophysical parameters for water yield calculation

Lucode	LULC_desc	Kc	Root_depth（mm）	Lulc_veg
1	Arbor forest	1	7000	1
2	Shrub wood	0.6	6000	1
3	Sparsewood	0.5	5500	1
4	Graden plot	0.6	2000	1
5	Nursery	0.5	1500	1
6	Other forest	0.45	3000	1
7	Nature grassland	0.65	1000	1
8	Artifical grassland	0.6	1000	1
9	Paddy field	0.75	700	1
10	Non-irrigated farmland	0.6	800	1
11	Water body	1	1	0
12	Building	0.3	1	0
13	Road	0.3	1	0
14	Bare soil	0.2	1	0
15	Others	0.3	1	0

2. Soil Retention

In InVEST Sediment Delivery Ratio (SDR) model, the Universal Soil Loss Equation (RUSLE) was used to calculate soil retention, the calculation formula are as follows :

$$RKLS_x = R_x \cdot K_x \cdot LS_x$$

$$USLE_x = R_x \cdot K_x \cdot LS_x \cdot C_x \cdot P_x$$

$$SEDR_x = SE_x \sum_{y=1}^{x=1} USLE_y \prod_{z=y+1}^{x=1} (1 - SE_z)$$

$$SEDRET_x = RKLS_x - USLE_x + SEDR_x$$

where R_x refers to rainfall erosivity factor (MJ·mm/ha·h·y); k_x refers to soil erodibility factor (t·ha·h/ha·MJ·mm); LS_x refers to the slope length factor and steepness(dimensionless); C_x is the vegetation management factor (dimensionless); Px is the soil practice factor(dimensionless),which was modified from wu et al[5] (Table S2); $SEDR_x$ is the amount of sediment intercepted by the grid unit (t/(hm^2·a)); RKLS-USLE is the sediment of the grid unit itself (t/(hm^2·a)); SEDRETx is the soil retention of grid unit x (t/(hm^2·a)).

Table S2 Biophysical table for the soil retention calculation

ID	LULC_desc	usle_c	usle_p
1	Arbor forest	0.02	1
2	Shurbwood	0.14	1
3	Sparse shurb	0.08	1
4	Mixed forest	0.06	1
5	Bamboo forest	0.02	1
6	Afforestation	0.004	1
7	Young plantation	0.08	1
8	Sparse shrub grass	0.22	1
9	Garden plot	0.089	0.69
10	Natural grassland	0.16	1
11	Artifical grassland	0.45	1
12	Paddy field	0	0.1
13	Non-irrigated farmland	0.57	0.3
14	Water body	0	0.1
15	Building	0.01	0.001
16	Road	0.01	0.001

17	Other construction	0.01	0.001
18	Desert	0.7	1

3. Carbon Storage

The InVEST Carbon Storage and Sequestration model combines land use data and four carbon pools to calculate the carbon storage of the ecosystem: aboveground biomass, belowground biomass, soil and dead organic matter

$$C_{\mathrm{i}} = \mathrm{C}_{\mathrm{i}(above)} + \mathrm{C}_{\mathrm{i}(below)} + \mathrm{C}_{\mathrm{i}(dead)} + \mathrm{C}_{\mathrm{i}(soil)}$$

Where C_i represents the carbon density (Mg/ha) of grid cell i; $C_{i\,(above)}$, $C_{i\,(below)}$, $C_{i\,(dead)}$, $C_{i\,(soil)}$ are aboveground biomass carbon density, belowground biomass carbon density, dead organic carbon density and soil organic carbon density (Mg/ha), respectively; the carbon density value used in the module mainly refers to the research of wang et al[6] (see Table S3).

Table S3 Carbon density of different land cover types in Beijing-Tianjin-Hebei region ($Mg \cdot hm^{-2}$)

ID	LULC_desc	$C_{i,above}$	$C_{i,below}$	$C_{i,soil}$	$C_{i,dead}$
1	Forest	30.23	9.07	151.4	3
2	Garden plot	13.13	3.94	110.6	0.51
3	Grassland	1.03	2.61	62.9	0.24
4	Paddy field	8.3	0.83	92.9	0
5	Non-irrigated farmland	6.6	0.66	92.9	0
6	Water	2.29	0	17.16	0
7	Urban land	7.61	4.51	42.17	0
8	Unutilized land	9.1	14.2	22.63	0

4. Heat mitigation

The module first calculates CC (Cooling Capacity) Index, and then further considers the influence of large-area green space (> 2ha) on the surrounding area to calculate the HM:

$$CC = 0.6 \cdot shade + 0.2 \cdot albedo + 0.2 \cdot ETI$$

$$HMI = \begin{cases} CC_i & if\ CC_i \geq CC_{parki}\ or\ GA_i < 2ha \\ CC_{parki} & otherwise \end{cases}$$

Where CC represents the cooling capacity index; shade represents the shading capacity provided by trees; albedo is the surface albedo; ETI refers to the evapotranspiration index. CC_{parki} is the cooling capacity of grid unit i calculated according to the distance from grid unit i to green space and CC value. GA_i is the amount of green areas within a search distance around each pixel; The shading capacity, surface albedo and maximum influence distance of green space of different land use types were set according to the research of Zawadzka et al[7] (see Table S4).

Table S4 Parameters of urban cooling module

lucode	LULC_desc	shade	kc	albedo	greenarea
1	Arbor forest	1	1	0.15	1
2	Shrub wood	1	0.6	0.23	1
3	Sparseshurb	1	0.5	0.2	1
4	Mix forest	1	0.45	0.15	1
5	Bamboo forest	1	0.45	0.15	1
6	Other forest	1	0.45	0.2	1
7	Garden plot	1	0.6	0.15	1
8	Nursery	1	0.5	0.15	1
9	Natural grassland	0	0.65	0.2	1
10	Artifical grassland	0	0.6	0.2	1
11	Paddy field	0	1	0.06	0
12	Non-irrigated farmland	0	0.6	0.25	0
13	Water	0	1	0.06	0
14	Multi-storey construction	0	0.3	0.15	0
15	Low-rise construction	0	0.3	0.18	0
16	Road	0	0.3	0.23	0
17	Other construction	0	0.3	0.16	0
18	Desert	0	0.2	0.25	0

Reference:

1. Canadell, J.; Jackson, R B.; Ehleringer, J B.; Mooney, H A.; Sala, O E.; Schulze, E D. Maximum rooting depth of vegetation types at the global scale. *Oecologia*. **1996**, 108(4): 583-595.
2. Schenk, H J.; Jackson, R B. Rooting Depths, Lateral Root Spreads and Below-Ground/Above-Ground Allometries of Plants in Water-Limited Ecosystems. *Journal of Ecology*. **2002**, 90(3): 480-494.
3. Allen R G.; Pruitt W O.; Raes D.; Martin, S S.; Luis, P. Estimating Evaporation from Bare Soil and the Crop Coefficient for the Initial Period Using Common Soils Information. *Journal of Irrigation and Drainage Engineering*. **2005**, 131(1): 14-23.
4. Quinn, P.; Beven, K.; Chevallier, P.; Planchon, O. The prediction of hillslope flow paths for distributed hydrological modelling using digital terrain models. *Hydrological Processes*. **1991**, 5(1):

59-79.

5. Jian-Sheng, W.; Feng, Z.; Yang, Gao. Peng Jian. Hotspot and relationship identification in multiple landscape services: A case study on an area with intensive human activities. *Ecological Indicators*. **2013**, 29: 529-537.
6. Xu-Yang, W.; Yu-Qiang, L.; Xiang-Wen, G.; Ya-Yi, N.; Yin-Qing, C.; Xiao-Ping, S.; Wei, L. Storage, pattern and driving factors of soil organic carbon in an ecologically fragile zone of northern China. *Geoderma*. **2019**, 343: 155-165.
7. Zawadzka, J E.; Harris, J A.; Corstanje, R. Assessment of heat mitigation capacity of urban greenspaces with the use of InVEST urban cooling model, verified with day-time land surface temperature data. *Landscape and Urban Planning*. **2021**, 214: 104163.