Supplementary Materials

1. Soil Conservation (SC)——RUSLE model

$$SC = R \times K \times LS \times (1 - C \times P)$$

where SC represents soil conservation (t hm^{-2} yr^{-1}), R represents the rainfall erosivity factor, K represents the soil erosion factor, LS represents the topography factor, C represents the vegetation cover factor, and P represents the support routine factor.

(1) Rainfall erosivity factor (R)

$$R = \sum_{i=1}^{12} 1.735 \times 10^{\left[1.5 \times \log_{10}(Pi^2/P) - 0.08188\right]}$$

where P_i is the total monthly rainfall (raster data, mm); P is the annual rainfall (raster data, mm); i is the month in a year, i values from 1 to 12. P_i and P are both interpolated from meteorological data.

(2) Soil erosion factor (K)

$$K = \{0.2 + 0.3\exp[-0.0256SAN(1 - \frac{SIL}{100})]\} \times (\frac{SIL}{CLA + SIL})^{0.3}$$

$$\times [1.0 - \frac{0.25C}{C + \exp(3.72 - 2.95C)}] \times [1.0 - \frac{0.7SNI}{SNI + \exp(-5.51 + 22.9SNI)}] \times 0.1317$$

where SAN, SIL, and CLA are the sand fraction (%), silt fraction (%), and clay fraction (%), respectively; C is the soil organic carbon content (%); $SNI = 1 - SAN/100$. SAN, SIL, CLA, C and SNI all calculated from HWSD V1.2 data in ArcGIS.

(3) Topography factor (LS)

$$L = (\alpha / 22.13)^{[\beta/(\beta+1)]}$$

$$\beta = (\sin\frac{\theta}{0.0896}) / \left[3.0 \times (\sin\theta)^{0.8} + 0.56\right]$$

$$S = \begin{cases} 10.8\sin\theta + 0.03 & \theta < 5° \\ 16.8\sin\theta - 0.5 & 5° \le \theta < 10° \\ 21.91\sin\theta - 0.96 & \theta \ge 10° \end{cases}$$

where α is the slope length, θ is the slope steepness (°). α and θ are calculated from DEM data in ArcGIS.

(4) Vegetation cover factor (C)

$$C = \begin{cases} 1 & f = 0 \\ 0.6508 - 0.3436 \lg(f) & 0 < f \leq 78.3\% \\ 0 & f > 78.3\% \end{cases}$$

$$f = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$$

where $NDVI_{min}$ and $NDVI_{max}$ refer to the regional minimum and maximum NDVI, respectively. f is calculated from annual NDVI data in ArcGIS.

(5) Support routine factor (P)

P factor is obtained by assigning values to land use data according to Table S1.

Table S1. P value of different land use types.

Land use type	Cropland	Forest	Grassland	Water	Construction land	Unused land
P	0.4	1	1	0	0	1

2. Sand Fixation (SF)——RWEQ model

$$SF = SL_r - SL$$

$$SL_r = \frac{2z}{S_r^2} Q_{rmax} e^{-(\frac{z}{S_r})^2}$$

$$SL = \frac{2z}{S^2} Q_{rmax} e^{-(\frac{z}{S})^2}$$

$$Q_{rmax} = 109.8(WF \cdot EF \cdot SCF \cdot K')$$

$$S_r = 150.71(WF \cdot EF \cdot SCF \cdot K')^{-0.3711}$$

$$Q_{max} = 109.8(WF \cdot EF \cdot SCF \cdot K' \cdot C)$$
$$S = 150.71(WF \cdot EF \cdot SCF \cdot K' \cdot C)^{-0.3711}$$

where SF represents the amount of sand fixation (kg m^{-2} yr^{-1}), SL_r represents potential wind erosion (kg m^{-2} yr^{-1}), SL is actual wind erosion (kg m^{-2} yr^{-1}), Z represents the length of the maximum wind erosion occurring from the downwind direction (m), Q_{rmax} is the potential transport capacity (kg m^{-1}), Q_{max} is the highest transport capacity (kg m^{-1}), S is the length of the critical field (m), and WF, EF represent the weather factor and soil erodibility factor, respectively, SCF is soil crust factor, K' is soil roughness, and C is vegetation factor.

(1) Weather factor (WF)

$$WF = Wf \times \frac{\rho}{g} \times SW \times SD$$

where W_f is the wind factor (m^{-3} s^{-3}), ρ is the air density (kg m^{-3}), g is the acceleration of gravity (usually 9.8 m s^{-2}), SW is the soil wetness factor; SD is the snow cover factor.

wind factor (W_f)

$$Wf = \frac{\sum_{i=1}^{N} WS_2(WS_2 - WS_t)^2 \times N_d}{N}$$

where WS_2 is the wind speed at the height of 2 m (m s^{-1}), calculated by interpolating wind speed data from meteorological stations; WS_t is the threshold wind speed at 2 m (assumed 5 m s^{-1}), N_d is the number of observation days, N is the number of wind speed observations.

air density (ρ)

$$\rho = 348.0(\frac{1.013 - 0.1183DE + 0.0048DE^2}{T})$$

where DE is the altitude (km), calculated from DEM data in ArcGIS; T is the absolute temperature (K), calculated from temperature interpolation data.

soil wetness factor (SW)

$$SW = \frac{ET_P - (R+I)\frac{R_d}{N_d}}{ET_P}$$

where ET_P is potential evaporation (mm), calculated from meteorological data; R is rainfall (mm), interpolated from meteorological station data; I is the amount of irrigation (mm), which was set to 0 in this study, R_d is the number of rainy days.

snow cover factor (SD)

$$SD = 1 - P(snowcover > 25.4mm)$$

where P is the probability that the depth of snow cover is greater than 25.4 mm, calculated from snow depth data in ArcGIS.

(2) Soil erodibility factor (EF)

$$EF = \frac{29.09 + 0.31Sa + 0.17Si + 0.33Sa/Cl - 2.59OM - 0.95CaCO_3}{100}$$

where Sa, Si, Cl, OM, and $CaCO_3$ are the content of sand, silt, clay, organic matter, and calcium carbonate (%), respectively. Sa, Si, Cl, OM, and $CaCO_3$ are calculated from HWSD V1.2 data in ArcGIS.

(3) Soil crust factor (SCF)

$$SCF = \frac{1}{1 + 0.0066(Cl)^2 + 0.021(OM)^2}$$

where Cl and OM are the content of clay and organic matter (%), respectively. Cl and OM are calculated from HWSD V1.2 data in ArcGIS.

(4) Soil roughness (K′)

$$K' = \cos\alpha$$

where α is slope gradient (°), α is calculated from DEM data in ArcGIS.

(5) Vegetation factor (C)

$$C = e^{-0.0438FVC}$$

$$FVC = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$$

where FVC is the vegetation coverage (%). FVC is calculated from annual NDVI data in ArcGIS.

3. Carbon Sequestration (CS)——CASA model

(1) Static parameter file:

Table S2. Static parameter table.

Vegetation type	NDVI$_{max}$	NDVI$_{min}$	SR$_{max}$	SR$_{min}$	ε$_{max}$
Forest	0.64	0.023	4.555555	1.05	0.389
Grassland	0.604	0.023	4.0505	1.05	0.542
Water	0.604	0.023	4.0505	1.05	0.542
Cropland	0.604	0.023	4.0505	1.05	0.542
Construction land	0.634	0.023	4.0505	1.05	0.542
Unused land	0.604	0.023	4.0505	1.05	0.542

(2) Vegetation type map: the land use data (raster data).

(3) NDVI: twelve months of NDVI data (raster data).

(4) Monthly average temperature: twelve months of monthly average temperature data (raster data, ℃).

(5) Total monthly precipitation: twelve months of total monthly precipitation data (raster data, mm).

(6) Monthly total solar radiation: twelve months of total solar radiation data (raster data, MJ m^{-2}).

4. Water Yield (WY)——InVEST model

(1) **Precipitation:** annual total precipitation (raster data, mm yr⁻¹).

(2) **Evapotranspiration:** annual total evapotranspiration (raster data, mm yr⁻¹).

(3) **Root Restricting Layer Depth:** soil depth data (REF_DEPTH) of HWSD V1.2 data (raster data, mm).

(4) **Plant Available Water Content:** PAWC (raster data).

$$PAWC = 54.509 - 0.132 sand\% - 0.003(sand\%)^2 - 0.055 silt\%$$
$$-0.006(silt)^2 - 0.738 clay\% + 0.007(clay)^2 - 2.688 OM\% + 0.501(OM\%)^2$$

where PAWC is the plant available water capacity, *sand*, *silt*, *clay*, and *OM* are the proportions of clay, sand, silt, and organic matter in the soil, respectively.

(5) **Land Use/Land Cover:** the land use data (raster data).

(6) **Biophysical Table:**

Table S3. Biophysical table.

description	lucode	root_depth	Kc	LULC_veg
Cropland	1	2100	0.65	1
Forest	2	7000	1	1
Shrub	3	5000	0.95	1
Grassland	4	2000	0.65	1
Water	5	1	1	0
Ice	6	1	1	0
Unused land	7	1	0.75	0
Construction land	8	1	0.3	0
Wetland	9	1	1	1

(7) **Z parameter:** Zhang parameter, conduct coefficient debugging based on the actual situation of the research area.

(8) **Watersheds:** boundary data of the research area (vector data).

(9) **Sub-Watersheds:** sub-watershed data is obtained by dividing small watersheds based on DEM data in ArcGIS (vector data).

5. Habitat Quality (HQ) ——InVEST model
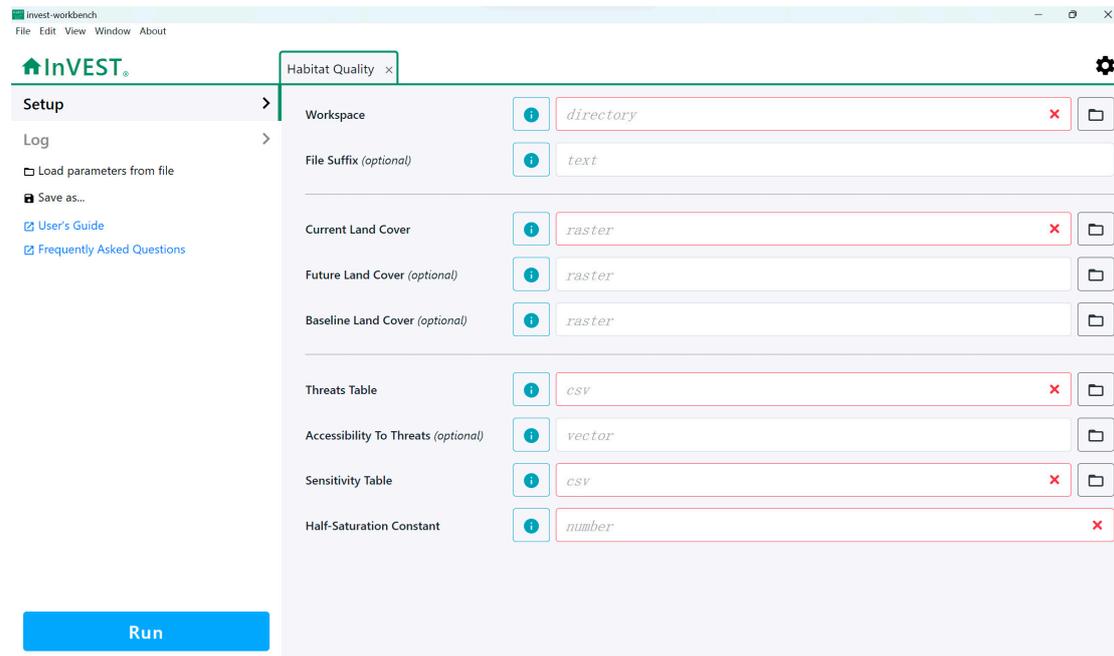
(1) Current Land Cover: the land use data (raster data).

(2) Threats Table:

Table S4. Attributes of threat factors.

Threat	Weight	Maximum effective distance (km)	Decay
Cropland	0.5	1.0	linear
Road	0.6	2.0	linear
Urban/built-up	1.0	5.0	exponential
Industrial	1.0	5.0	exponential
Rural	0.5	3.0	exponential

(3) Sensitivity Table

Table S5. Habitat sensitivity to threats.

Land use	Habitat suitability	Cropland	road	Urban/built-up	Industrial	Rural
Cropland	0.5	0.3	0.3	0.4	0.5	0.3
Forest	1.0	0.5	0.5	0.6	0.7	0.5
Grassland	0.7	0.3	0.3	0.4	0.5	0.3
Construction land	0.0	0.0	0.0	0.0	0.0	0.0
Unused land	0.0	0.0	0.0	0.0	0.0	0.0
Water	0.8	0.7	0.0	0.5	0.6	0.8

(4) Half-Saturation Constant: 0.05

6. Model validation

Table S6. Comparison of the results of five ecosystem services with previous studies.

Ecosystem services	Study area	Time of study	Values	Reference
Soil Conservation (RUSLE model) (t hm^{-2} yr^{-1})	Qinghai Tibet Plateau	2002-2050	21.85-22.70	Teng et al., 2018 [1]
	Heihe River Basin	2000-2008	10.84-11.43	Yan et al., 2014 [2]
	Central Asia	1996-2060	8.09-8.17	Ma, 2021 [3]
Sand Fixation (RWEQ model) (kg m^{-2} yr^{-1})	Northwest arid region	1990-2015	70.84	Chi et al., 2019 [4]
	Horqin Sandy Land	2010-2016	90.47	Zhang et al., 2019 [5]
	Loess Plateau	2000-2015	80.84	Wu et al., 2019 [6]
Carbon Sequestration (CASA model) (gC m^{-2} yr^{-1})	Northwest arid region	2000-2012	556	Li et al., 2018 [7]
	Qinghai Tibet Plateau	1982-1999	511	Piao et al., 2002 [8]
	Central Asia	1980-2100	384	Ma, 2021 [3]
Water Yield (InVEST model) (mm yr^{-1})	Yellow River Basin	1995-2018	214	Yang et al., 2021 [9]
	Heihe River Basin	1996-2060	83	Geng et al., 2015 [10]
	Central Asia	1996-2060	117	Ma, 2021 [3]
Habitat Quality (InVEST model)	Qinghai Tibet Plateau	1995-2015	0.62	Zhu et al., 2020 [11]
	Heihe River Basin	2000-2014	0.32	Wang et al., 2017 [12]
	Central Asia	1996-2060	0.36	Ma, 2021 [3]

7. Correlation analysis of influencing factors in Geographical detector

Table S7. Pearson correlations between pairs of influencing factors by Geographical detector in 2020.

Impact factors	Tem	Pre	Win	NDVI	Land use	Slope	DEM	Soil type
Tem	1							
Pre	0.014	1						
Win	0.171*	-0.733**	1					
NDVI	0.131**	0.517**	-0.338**	1				
Land use	-0.052	-0.151*	0.164*	-0.406**	1			
Slope	0.018	0.230**	0.048	0.211**	-0.038	1		
DEM	-0.288**	0.413**	0.163*	0.375**	0.037	0.445**	1	
Soil type	-0.160**	0.087	0.322**	0.223**	0.071	0.376**	0.659**	1

Note: Tem is temperature, Pre is precipitation, and wind is wind speed. * Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

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