sustainability

MDPI

SUPPLEMENTARY INFORMATION

Supplementary Materials_A

1. Methods

Water Conservation (WC), the estimation of water conservation capacity in InVEST model is mainly based on the water yield module, combined with terrain factors, soil types and soil permeability factors to calculate the water conservation capacity of the study area [1–3]. The specific calculation formula is as follows:

$$Y_{xj} = \left(1 - \frac{AET_{xj}}{P_x}\right) \times P_x \tag{1}$$

$$\frac{AET_{xj}}{P_x} = \frac{1 + \omega_x R_{xj}}{1 + \omega_x R_{xj} + \frac{1}{R_{xj}}} \tag{2}$$

$$R_{xj} = \frac{K_{xj} \times ET_{ox}}{P_x} \tag{3}$$

$$WC = \min(1249/V) \times \min(1, 0.9 \times TI/3) \times \min(1, K/300) \times Y \tag{4}$$

where Y_{xj} (mm) is the annual water supply of land use type j in grid unit x; AET_{xj} (mm) is the annual actual evapotranspiration of land use type j in grid unit x; P_x (mm) is the annual precipitation of grid unit x; Z is the seasonal constant, and the value range is generally between 0 and 30. In this study, the Z value is determined by the total amount of surface water resources in BTH in Haihe River water resources bulletin, so as to reduce the error between the simulation results and the measured data; R_{xj} is Budyko dryness index; ET_{ox} is the annual average evapotranspiration of the reference crop; V is runoff coefficient, TI is terrain index, K is soil saturated hydraulic conductivity, Y is annual water yield, WC is annual water conservation.

Soil Conservation (SC), the Sediment Delivery Ratio model in InVEST model could be divided into two parts: sediment retention and soil erosion reduction. The former is the difference between potential soil erosion and actual soil erosion, and the latter is the sediment retention of the plot on its uphill, the product of sediment and sediment retention rate is expressed [4]. The calculation formula of the model is as follows:

$$SEDRET_x = R_x \times K_x \times LS_x \times (1 - C_x \times P_x) + SEDR_x \tag{5}$$

$$SEDR_x = SE_x \sum_{y=1}^{x-1} USLE_y \prod_{z=y+1}^{x-1} (1 - SE_z) \tag{6}$$

$$USLE_x = R_x \times K_x \times LS_x \times C_x \times P_x \tag{7}$$

Where $SEDRET_x$ and $SEDRx$ are the soil retention and sediment retention of grid x, respectively; $USLEx$ and $USLEy$ are the actual soil erosion amount of grid X and its uphill

grid y, respectively; *Sex* stands for the sediment retention efficiency of grid X; R_x, K_x, LS_x, C_x and P_x represent rainfall erosivity factor, soil erodibility factor, slope length factor, vegetation and management factor and soil and water conservation measure factor of grid x, respectively. C_x and P_x are vegetation and management factors and soil and water conservation measures factors, respectively, which are determined by referring to relevant research results of Hebei Province [5].

Table S1. Vegetation management factor C and soil and water conservation measure factor P of different land use.

Land use	Paddy field	Dry land	Forestland	Grassland	Wet land	Construction land	Unused land
C	0.04	0.08	0.003	0.04	0	0.001	1
P	0.15	0.55	1	1	0	0.001	1

Habit Quality (HQ), habitat quality refers to the suitability evaluation of the combination of habitat factors in the ecosystem, human survival and social and economic sustainable development in a specific space-time range [6]. Habitat index can reflect the habitat quality. The specific calculation formula is as follows:

$$Q_{xj} = H_j \left[1 - \left(\frac{D_{xj}^z}{D_{xj}^z + k^z} \right) \right] \tag{8}$$

where Q_{xj} is the habitat quality of grid x in land use type j; H_j is the habitat suitability of land use type *j*; D_{xj} is the habitat degradation degree of land use type *j*; *K* is the semi saturation constant; *Z* is a normalized constant, usually taking the default parameter value of 2.5.

Net Primary Productivity (NPP), the net primary productivity (NPP) of vegetation is simulated by CASA model. The principle of the model is to estimate NPP of vegetation by simulating light and effective radiation of vegetation and actual light energy utilization rate [7]. The specific formula is as follows：

$$NPP(x, t) = APAR(x, t) \times \varepsilon(x, t) \tag{9}$$

$$APAR(x, t) = SOL(x, t) \times FPAR(x, t) \times 0.5 \tag{10}$$

Where APAR*(x, t)* is the photosynthetically active radiation absorbed by pixel *x* in month *t*; *ε(x, t)* is the light energy utilization rate of pixel X in t month. *SOL(x, t)* is the total solar radiation of pixel *x* in *t* month, *FPAR (x, t)* is the absorption ratio of vegetation layer to the incident photosynthetically active radiation, and constant 0.5 is the proportion of solar effective radiation that vegetation can use to the total solar radiation.

Reference

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Supplementary Materials_B

Table S2. The proportions of ecosystem service hotspots in in BTH and all ecological regions.

		0	1	2	3	4
2000	A	42.75	21.18	22.12	9.84	4.11
	B	4.88	13.54	18.05	27.64	35.87
	C	14.11	26.13	22.33	17.59	19.84
	D	11.39	24.25	22.42	20.45	21.48
	E	19.76	55.46	23.35	1.1	0.33
	F	10.19	47.3	42.42	0.08	0.01
	G	19.59	76.31	4.09	0	0
	BTH	13.78	33.29	26.15	12.5	14.28
2010	A	50.86	16.09	17.7	12.63	2.71
	B	5.87	11.92	15.94	32.25	34.03
	C	23.74	21.45	19.84	18.57	16.4
	D	20.58	16.89	19.86	23.16	19.5
	E	58.42	32.39	8.22	0.72	0.25
	F	67.43	31.64	0.84	0.08	0
	G	76.99	22.78	0.23	0	0
	BTH	38.65	22.29	11.76	14.28	13.03
2020	A	58.38	2.75	24.22	11.66	2.99
	B	12.3	9.81	16.77	30.69	30.43
	C	32.41	7.78	22.05	21.74	16.03
	D	22.66	9.03	16.17	26.97	25.17
	E	80.2	15.11	2.71	1.68	0.3
	F	67.74	31.35	0.66	0.23	0.02
	G	92.64	6.94	0.31	0.1	0
	BTH	45.53	15.17	11.36	14.93	13.01
2030_BAU	A	58.38	2.75	24.22	11.66	2.99
	B	12.3	9.81	16.77	30.69	30.43
	C	32.41	7.78	22.05	21.74	16.03
	D	22.66	9.03	16.17	26.97	25.17
	E	80.2	15.11	2.71	1.68	0.3
	F	67.74	31.35	0.66	0.23	0.02
	G	92.64	6.94	0.31	0.1	0
	BTH	45.53	15.17	11.36	14.93	13.01
2030_ED	A	61.8	5.96	14.74	13.68	3.82
	B	7.84	15.23	14.85	24.34	37.73
	C	30.49	12.52	16.73	18.81	21.44
	D	22.1	11.21	16.1	20.21	30.38
	E	80.76	17.94	1.19	0.08	0.03
	F	54.71	44.4	0.8	0.08	0.01
	G	95.21	4.79	0	0	0
	BTH	41.43	21.28	9.29	11.94	16.07

2030_EC	A	61.57	5.85	15.23	13.53	3.83
	B	7.41	12.2	11.08	27.31	42
	C	29.76	10.95	16.55	20.14	22.6
	D	21.6	9.22	13.65	22.2	33.33
	E	79.86	17.29	1.63	0.76	0.45
	F	55.4	43.61	0.85	0.11	0.03
	G	95.45	4.55	0	0	0
	BTH	41.21	19.78	8.14	13.18	17.7