Supplementary Information

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Specific landscape types may have positive or negative impacts on ecosystem service provision when adjacent to other landscape types. For instance, forest ecosystems may benefit the ecosystems around them, and there are good linkages in the provision of ecosystem services from the forest to neighboring land use types. However, built-up land dominated by humans may cause harm to the natural ecosystems in its vicinity, and this connection can lead to functional degradation of the surrounding ecosystems. Therefore, the spatial adjacency effect coefficient (SAEC) of ecosystem services for different landscape types was incorporated according to the coefficient matrix scored by experts[1-3].

Table S1. Coefficient matrix for the spatial neighboring effect on the ecosystem services of each landscape type

Adjoining pixel type	Target pixel type						
	Forestland	Grassland	Water body	Farmland	Barren land	Built-up land	Wetland
Forestland	+5	+5	+5	+4	+4	+4	+5
Grassland	+4	+5	+4	+2	+3	+3	+4
Water body	+5	+4	+5	+2	+4	+4	+4
Farmland	-1	-1	-4	+2	-1	+1	-3
Barren land	-1	-2	+5	-3	+1	-1	-3
Built-up land	-2	-3	-5	+2	-2	+1	-4
Wetland	+4	+3	+5	+2	+3	+3	+5

Table S2. Coefficients of resistance and resilience of each land use type.

Land use type	Farmland	Forestland	Grassland	Water body	Wetland	Built-up land	barren land
$C_{resistan}$	0.5	1	0.7	0.8	0.6	0.3	0.2
$C_{resilien}$	0.3	0.6	0.8	0.7	0.7	0.2	0.1

Table S3. The calculation methods of ecosystem services

Ecosystem services	**Calculation method**
Food production (t/hm²)	The total food production (FP) of a region is allocated to each grid of arable land according to the ratio of the grid's NDVI value to the NDVI value of all farmlands [4]: $G_i = \frac{NDVI_i}{NDVI_{sum}} \times G_{sum}$ Where G_i donates food yield of grid i; G_{sum} is the the total food output; $NDVI_i$ is the NDVI value of grid i of farmland; $NDVI_{sum}$ is the sum of the NDVI value of all farmlands.
Water yield (mm)	The water balance equation [5,6] in the InVEST model is employed to calculate the water yield (WY) of the YRB: $WY = (1 - \frac{AET_{xj}}{P_x}) \times P_x \qquad \frac{AET_{ij}}{P_X} = (1 + \omega_x R_{ij}) / (1 + \omega_x R_{ij} + 1/R_{ij})$ $R_{ij} = K_{ij} \times ET_o / P_x \qquad \omega_x = Z \times AWC_x / P_X$ $AWC = Min(Soil\ Depth, Root\ Depth) \times PAWC$ Where WY donates the annual water yield (mm) of land use type j in grid x, AET_{xj} is the average annual actual evapotranspiration of grid x (mm); P_x is the average annual precipitation (mm) of grid x; R_{xj} is the Budyko aridity index (dimensionless) of grid x; K_{xj} is the coefficient of vegetation evapotranspiration; ET_0 is the potential evapotranspiration (mm); ω_x is a dimensionless ratio characterizing the natural climate and soil properties; AWC_x is the volumetric (mm) plant available water content; and $PAWC$ is the plant available water capacity (0-1). Z is the Zhang coefficient [7], which ranges from 1 to 10 and

needs to be calibrated with monitoring data from the local hydrometric stations.

Carbon storage (t/hm²)

Using maps of land use and land cover (LULC) types and the amount of carbon stored in carbon pools, carbon storage and sequestration (CSS) module in the InVEST model is employed to estimate the net amount of carbon stored in a land parcel over time:

$$C_{total} = C_{above} + C_{below} + C_{soil} + C_{dead}$$

where C_{total} is the total amount of carbon storage and C_{above}, C_{below}, C_{soil}, and C_{dead} represent the amount of carbon stored in aboveground biomass, belowground biomass, soil, and dead organic matter, respectively, all in t·hm^{-2}.

Soil conservation (t/hm²)

The revised universal soil loss equation (RUSLE) [8] is employed to calculate the soil conservation of the YRB:

$$A = R \times K \times LS \times (1 - CP) \qquad R = \sum_{i=1}^{12} 1.735 \times 10^{(1.5 \times \lg \frac{P_i^2}{P} - 0.8188)}$$

$$K = \left\{0.2 + 0.3\exp\left[-0.0256SAN\left(1 - \frac{SIL}{100}\right)\right]\right\} \times \left(\frac{SIL}{CLA + SIL}\right)^{0.3} \times \left[1 - \frac{0.25TOC}{TOC + \exp(3.72 - 2.95TOC)}\right] \times \left[1 - \frac{0.7SNI}{SNI + \exp(22.9SNI - 5.51)}\right]$$

$$L = (\lambda / 22.13)^m \begin{cases} m = 0.5 & \theta > 9\% \\ m = 0.4 & 3\% < \theta \leqslant 9\% \\ m = 0.3 & 1\% < \theta \leqslant 3\% \\ m = 0.2 & \theta \leqslant 1\% \end{cases} \qquad S = \begin{cases} 10.8\sin\theta + 0.03 & \theta < 5^0 \\ 16.8\sin\theta - 0.50 & 5^0 \leqslant \theta \leqslant 5^0 \\ 21.9\sin\theta - 0.96 & \theta \geqslant 10^0 \end{cases}$$

$$C = \begin{cases} 1 & fvc = 0 \\ 0.6508 - 0.3436\lg fvc & 0 < fvc \leqslant 78.3\% \\ 0 & fvc > 78.3\% \end{cases} \qquad fvc = \frac{NDVI_i - NDVI_{\min}}{NDVI_{\max} - NDVI_{\min}} \qquad P = 0.2 + 0.03\alpha$$

Where A donates soil conservation (t·hm^{-2}), R is the precipitation erosion factor, K is the soil erodibility factor [9], LS is the slope length and steepness factor, C is the cover and management factor [10], P is the erosion control practice factor [11]. P_i is the rainfall in month i (mm) and P is the average annual precipitation (mm). SAN, SIL, CLA, and TOC are the percentages of sand, silt, clay, and organic carbon, respectively, in the soil and 0.1317 is the conversion coefficient from the US system to the metric system. λ is the slope length (m), m is the slope length index, and θ is the percentage of the pixel slope that is generated from DEM. $NDVI_{min}$ is the minimum NDVI, $NDVI_{max}$ is the maximum NDVI, f is the degree of vegetation cover, and C is the cover and management factor.

Wind prevention and sand fixation (t/hm²)

The ecosystem service of wind prevention and sand fixation function (WPDF) is measured by the reduction of wind erosion volume from the presence of surface by Revised Wind Erosion Equation (RWEQ) model [12,13].

$$SR = SL_{\max} - SL_r \qquad SL_{max} = \frac{2z}{S^2} \times Q_{max} \times e^{-(Z/S)^2} \qquad SL_r = \frac{2z}{S^2} Q_{rmax} \times e^{-(Z/S)^2}$$

$$Q_{max} = 109.8 \times (WF \times EF \times SCF \times K' \times COG) \qquad Q_{rmax} = 109.8 \times (WF \times EF \times SCF \times K')$$

$$S = 150.71 \times (WF \times EF \times SCF \times K' \times COG)^{-0.3711} \qquad S_r = 150.71 \times (WF \times EF \times SCF \times K')^{-0.3711}$$

$$WF = wf \times \left(\frac{\rho}{g}\right) \times SW \times SD \qquad wf = (U_2 - U_1)^2 \times U_2 \times N_d$$

$$EF = \frac{29.09 + 0.31SAN + 0.17SIL + 0.33(SAN/CLA) - 2.59OM - 0.95CaCO_3}{100}$$

	$SCF = \frac{1}{1+0.0066(CLA)^2+0.021(OM)^2}$ $K' = \cos(S)$ $COG = e^{-ai(fvc)}$ Where SL_{max} and SL_r correspond to the potential and actual wind erosion (kg·m^{-2}), respectively. The former refers to the maximum possible wind erosion without vegetation cover, which is a hypothetical counterfactual value; the latter is the wind erosion under the current vegetation cover. Q_{max} and Q_{rmax} are the maximum and actual sand transport quantity, respectively. *WF*, *EF*, *SCF*, K', and *COG* are weather factor, soil erodibility index, soil crust factor, roughness factor, and vegetation factor, respectively. *S* and S_r are the critical curve lengths. *WF* is the wind coefficient. *g* is the acceleration of gravity (m·s^{-2}); ρ is the density of air (kg·m^{-3}); SW is the soil moisture factor (dimensionless); *SD* is the snow factor (dimensionless); u_2 is the average wind speed (m·s) at a height of 2 m; N_d is the number of days with wind speed greater than 5m/s at 2m during the observation period. *SAN, SIL* and *CLA* refer to soil sand content (%), soil silt content and soil clay content, *OM* refers to soil organic matter content (%), and $CaCO_3$ refers to calcium carbonate content (%). *SAN*/*CLA* indicates the sand to clay ratio. *fvc* refers to vegetation coverage; *ai* represents the coefficient of each vegetation type, which is: farmland 0.0438, forestland 0.1535, grassland 0.1151, barren land 0.0921, built-up land, water area and wetland default 0.
Water purification (kg/hm²)	Nutrient export (including negative indicators of nitrogen export and phosphorus export) from each pixel is calculated based on the product of the load and the nutrient delivery ratio (NDR) module in the InVEST model [4,14]: $X_{export_i} = load_{surf,i} \times NDR_{surf,i} + load_{subs,i} \times NDR_{subs,i}$ $X_{export_{tot}} = \sum_i X_{export_i}$ $load_{surf,i} = (1 - proportion_subsurface_i) \times \text{mod}ified_load_i$ $load_{subsurf,i} = proportion_subsurface_i \times \text{mod}ified_load_i$ $\text{mod}ified_load_i = load_i \times RPI_i$ $RPI_i = \frac{RP_i}{RP_a}$ where RPI_i is the runoff potential index for pixel *i*, RP_i is the nutrient runoff proxy for runoff on pixel *i*, and RP_a is the average *RP* over the entire area.
Habitat quality	Hability quality module in the InVEST model is employed to calculate the habitat quality (HY) of the YRB: $Q_{ij} = H_j(1 - \frac{D_{ij}^z}{D_{ij}^z + k^z})$ Where Q_{ij} donates the habitat quality of grid *i* in land use type *j* (unitless). H_j is the habitat suitability of land use type *j*. D_{ij} the habitat degradation index. *k* is the half-saturation coefficient. *Z* is a normalized constant, which is set to 2.5 [15].

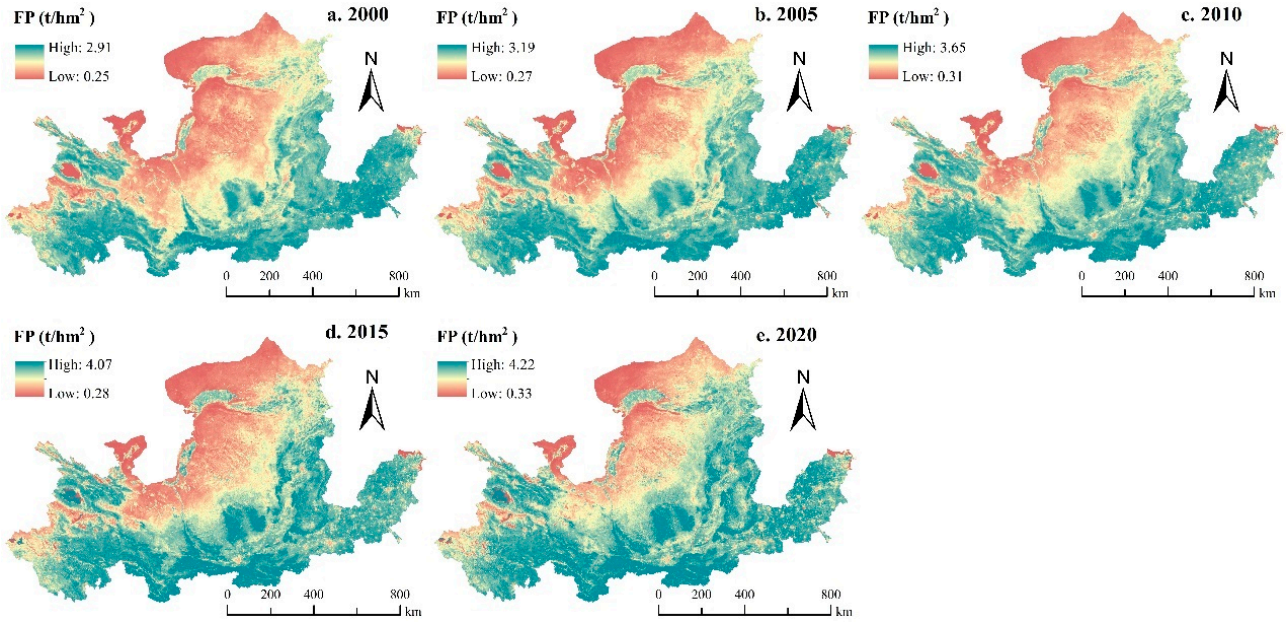

Figure S1. Spatial pattern of food production in the YRB from 2000 to 2020.

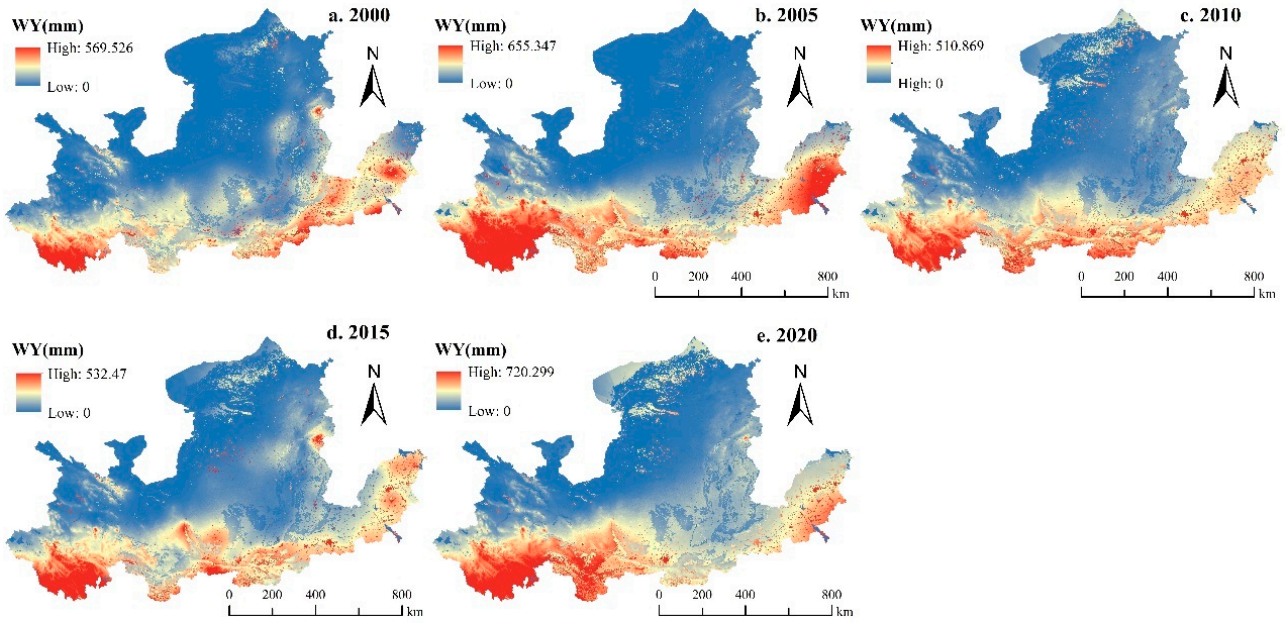

Figure S2. Spatial pattern of water yield in the YRB from 2000 to 2020.

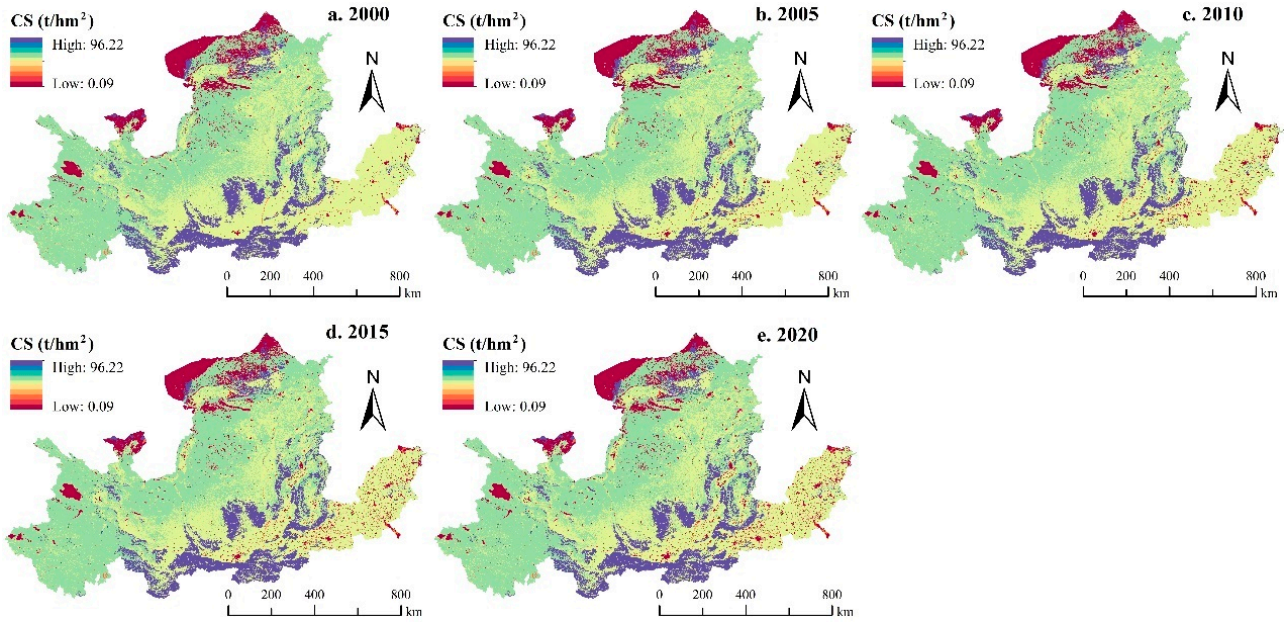

Figure S3. Spatial pattern of carbon storage in the YRB from 2000 to 2020.

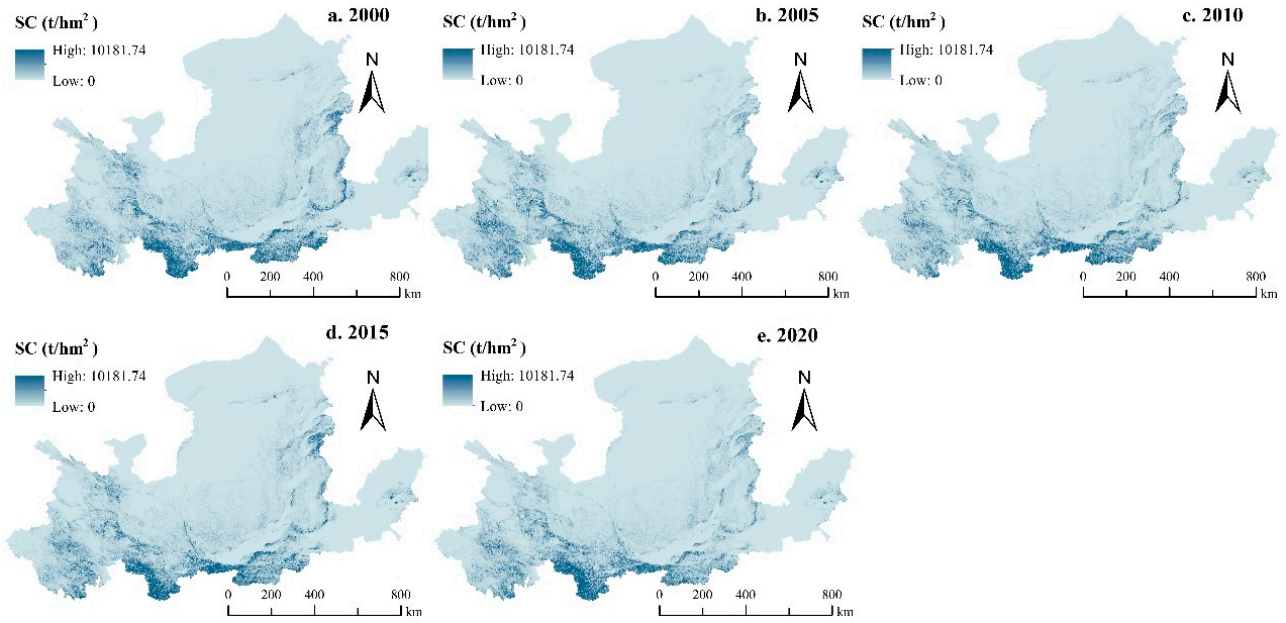

Figure S4. Spatial pattern of soil conservation in the YRB from 2000 to 2020.

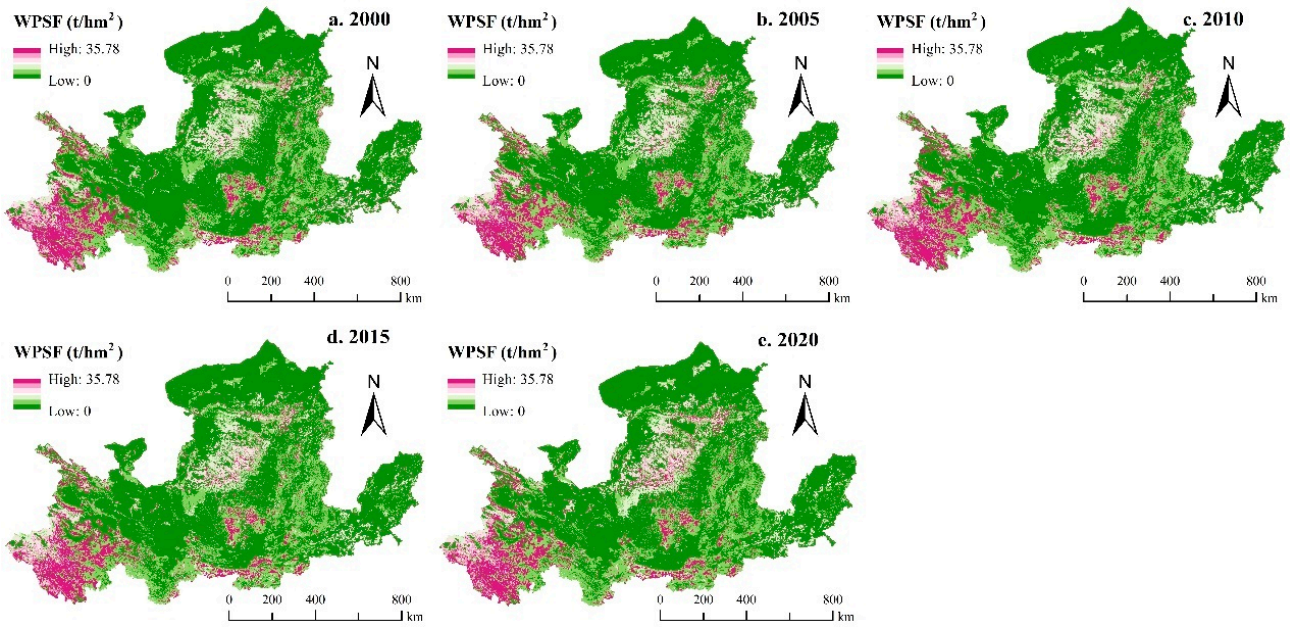

Figure S5. Spatial pattern of wind prevention and sand fixation in the YRB from 2000 to 2020.

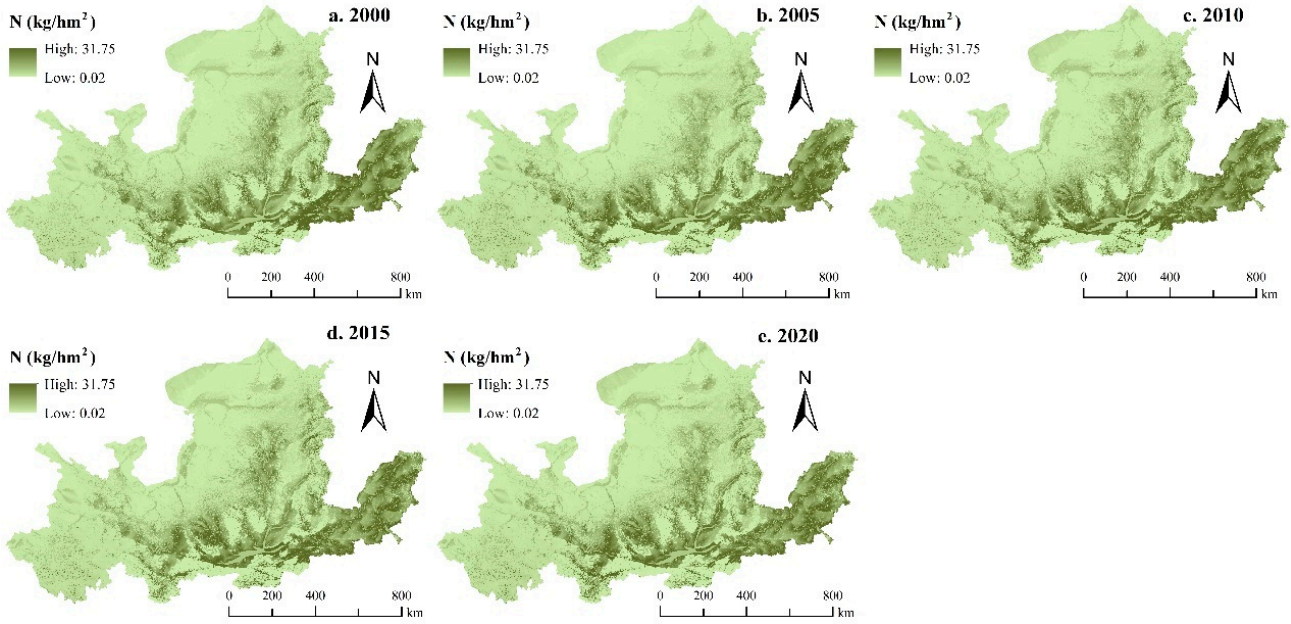

Figure S6. Spatial pattern of nitrogen export in the YRB from 2000 to 2020.

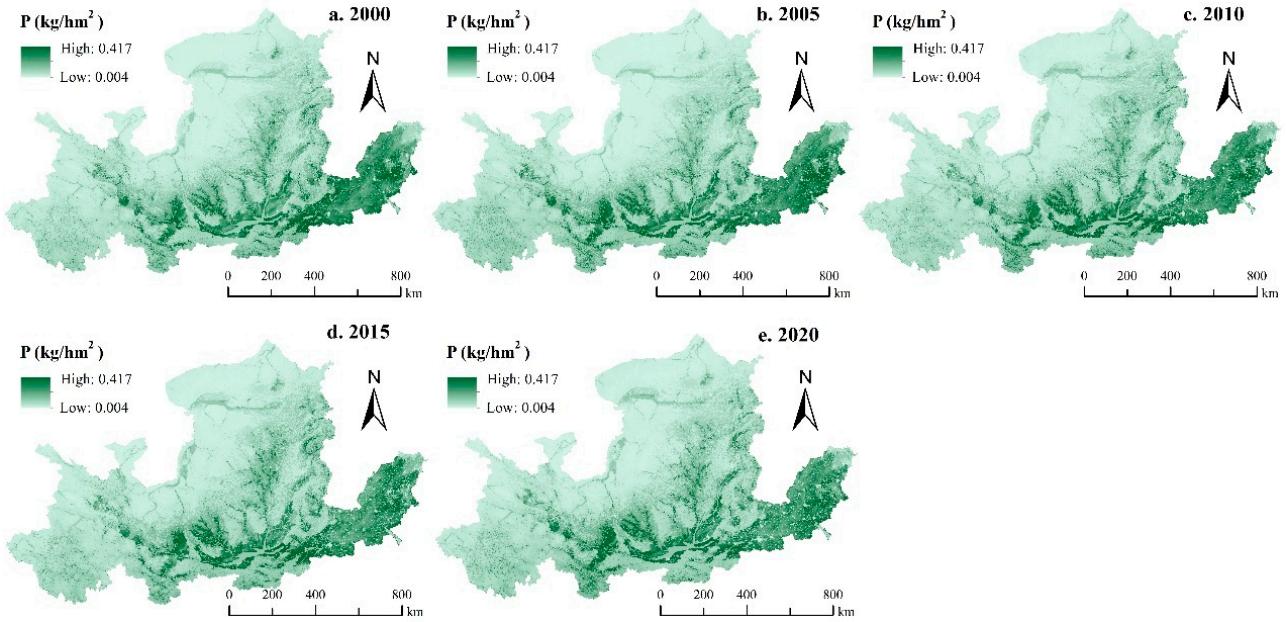

Figure S7. Spatial pattern of phosphorus export in the YRB from 2000 to 2020.

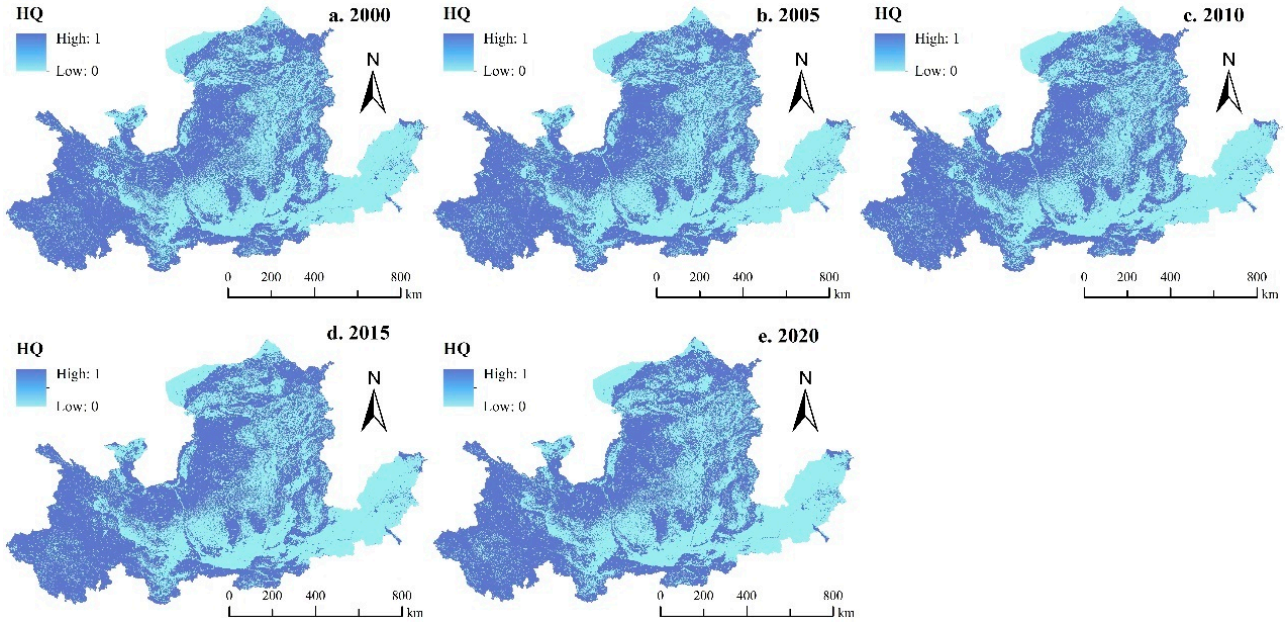

Figure S8. Spatial pattern of habitat quality in the YRB from 2000 to 2020.

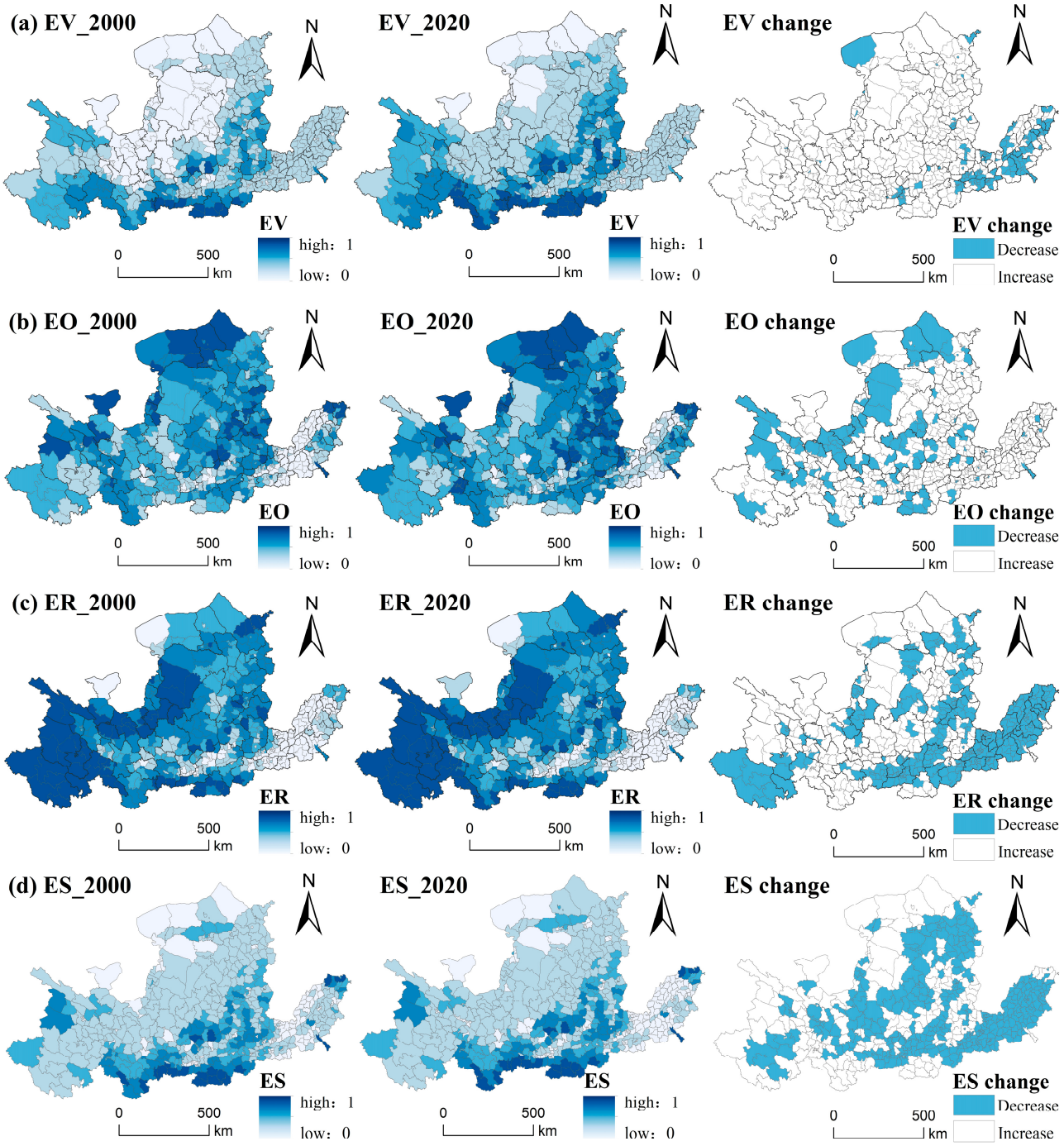

Figure S9. Spatial-temporal evolution of ecosystem vigor, organization, resilience and service in 2000 and 2020.

Notes: (a) ecosystem vigor (EV), (b) ecosystem organization (EO), (c) ecosystem resilience (ER), and (d) ecosystem service (ES).

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