Supplementary Materials

NDVI interannual variations at a pixel scale

$$\theta_{slope} = \frac{n \times \sum_{i=1}^{n} i \times NDVI_i - \sum_{i=1}^{n} i \times NDVI_i}{n \times \sum_{i=1}^{n} i^2 - (\sum_{i=1}^{n} i)^2} \quad \text{(S1)}$$

In this expression, θ_{slope} denotes the slope of the fitted trend line, n is the study time, and $NDVI_i$ denotes the NDVI in year i. This paper uses an F-test to test the confidence level of the interannual NDVI trend change. When $\theta_{slope} < 0$ and $P < 0.01$ indicates a highly significant decrease in NDVI. $\theta_{slope} < 0$ and $0.01 \leq P < 0.05$ indicate a significant decrease in NDVI. $P \geq 0.05$ indicates no significant change. $\theta_{slope} > 0$ and $0.01 \leq P < 0.05$ indicate a significant increase. $\theta_{slope} > 0$ and $P < 0.01$ indicate a highly significant increase. As a result, a statistically significant trend that is statistically too tiny or an error that is less than the NDVI time series should not be regarded significant. It is more important to assess the relative change in inter-annual NDVI while masking inconsequential pixels in terms of both statistics and magnitude.

Quantifying Ecosystem Services

1) Annual water yield

Water resources are very sensitive and limited, especially in the semi-arid LP. The water yield is defined as the amount of runoff water for all land use types based on the water balance principle. Based on the soil texture (% clay grain content, % sand grain content, % powder grain content) the plant available water fraction was calculated using the empirical formula [64]. The water yield per raster unit is calculated using the average annual precipitation and the actual annual evapotranspiration as follows：

$$Y(x) = \left\{1 - \frac{AET(x)}{P(x)}\right\} \times P(x) \qquad \text{(S2)}$$

where $AET(x)$ is the actual annual evapotranspiration at pixel x and $P(x)$ is the annual precipitation at pixel x. The detailed procedure for calculating $AET(x)$ can be found in the InVEST user manual [65]. The model generates the water yield of the LP.

2) Soil erosion control

Soil erosion control is one of the most critical Ecosystem services in all land uses, especially in the LP, which has suffered from severe soil erosion in recent decades. Reduction of soil loss implies improvement of soil erosion control. Soil conservation is defined as potential soil loss under extreme degraded conditions minus soil loss under current land use/land cover scenarios. Soil retention is therefore a relative measure of soil loss and is one of the most important indicators to reflect soil erosion control. The model equation is as follows：

$$USLE_x = R_x \times K_x \times LS_x \times C_x \times P_x \qquad \text{(S3)}$$

where LS_x is the potential soil erosion of grid x; $USLE_x$ is the actual soil erosion of grid x; R_x is the rainfall erosion force, calculated by reference to [61]; K_x is the soil erodibility using the EPIC model [66]; LS_x is the slope length-gradient factor calculated [67] for two dimension surfaces; C_x is the vegetation cover factor using plant cover [68]; and P_x is the management factor setting with related previous studies [62].

3) Carbon sequestration

The carbon storage module of the InVEST model uses land use maps and the carbon density corresponding to each land use type for estimating carbon storage per pixel unit. Carbon stocks in regional terrestrial ecosystems include aboveground biogenic carbon, belowground biogenic carbon, soil carbon, and dead organic carbon. The carbon stock data of the four reservoirs were set up with reference to the studies of [69,70]. In this study, the carbon storage change in each unit was assessed based on the spatial distribution pattern of land use, cover type and corresponding carbon density. Finally, this study generated the spatial distribution of carbon storage in different land use types.

The amount of carbon sequestration over time for a given parcel x is:

$$C_{tot} = C_a + C_b + C_s + C_d \qquad \text{(S4)}$$

where C_{tot} denotes the amount of carbon storage, C_a represents carbon density of aboveground biomass, C_b is the carbon density of belowground biomass, C_s is the carbon density of soil, C_d is the carbon density of dead matter.

4) Habitat provisioning for biodiversity

Ecosystem services are closely related to biodiversity. The increased land use intensity threat to the ecological environment from increased land use intensity is subsequently exacerbated. Ecosystems become less capable of providing a suitable living environment for organisms, and consequently biodiversity decreases. Therefore, land use can serve to assess the threat to habitats. It is crucial to determine the level of threat posed by different land types to the habitat, the spatial distance and magnitude of the weights, the relative sensitivity of the habitat to potential threats. This study's sensitivity coefficient table and threat factor coefficient table were set up based on existing scholarly work [64,71,72]. The formula is as follows:

$$D_{xj} = \sum_{1}^{r} \sum_{1}^{y} \left(\frac{\omega_r}{\sum_{r=1}^{n} \omega_r} \right) \times r_y \times i_{rxy} \times \beta_x \times S_{jr} \qquad \text{(S5)}$$

$$i_{rxy} = \begin{cases} 1 - \left(\frac{d_{xy}}{d_{rmax}}\right) \\ \exp\left[-\left(\frac{2.99}{d_{rmax}}\right) \times d_{xy}\right] \end{cases} \quad (S6)$$

$$Q_{xj} = H_{xj} \times \left[1 - \left(\frac{D_{xj}^2}{D_{xj}^2 + k^2}\right)\right] \quad (S7)$$

where D_{xj} is the habitat degradation degree, representing the degree of habitat degradation of raster x in land use type j. ω_r is the weight of different threat factors; is the intensity of stress factors; r_y is the level of habitat resistance to disturbance; β_x is the relative sensitivity of different habitats to different threat factors [71,72]; S_{jr} is the effect of threat factor r in raster y on raster x; i_{rxy} is the habitat threat factor; y is the raster in threat factor r; d_{xy} the distance between raster x and raster y; d_{rmax} is the influence range of threat factor r. Q_{xj} is the habitat quality of raster x in land use type j; Habitat quality values ranged from 0 to 1, and higher Q_{xj} values indicated better habitat quality, and H_{xj} is the habitat adaptability of raster x in land use type j; k is the half-saturation constant.

The geographical detector technique

Factor detector

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{SSW}{SST} \quad (S8)$$

where q is the explanatory power of each influence factor on the ecosystem service trade-offs/synergies relationship, and the value range of q is [0,1]. h =1, ..., L is the strata of variable ecosystem service trade-offs/synergies 's or factor X; N_h and N are the number of cells in stratum h and the whole area, respectively; σ_h^2 and σ^2 are the variance of ecosystem service trade-offs/synergies values in stratum h and the whole area, respectively. SSW and SST are the within sum of squares and total sum of squares, respectively. Larger q values indicate more pronounced spatial heterogeneity of ecosystem service trade-offs/synergies; if the stratification is generated by the independent variable X, larger q values indicate stronger explanatory power of the independent variable X on the attribute Y, and vice versa. In the extreme case, a q value of 1 indicates that factor X completely controls the spatial distribution of ecosystem service trade-offs/synergies, a q value of 0 indicates that factor X has no relationship with ecosystem service trade-offs/synergies, and a q value indicates that X explains 100 × q% of ecosystem service trade-offs/synergies [52].

Trade-Offs/Synergies Between Ecosystem Services

$$ES_{i,std} = \frac{ES_{i,obs} - ES_{i,min}}{ES_{i,max} - ES_{i,min}} \quad \text{(S9)}$$

where $ES_{i,std}$ is the normalized value of any ecosystem service, $ES_{i,obs}$ is the value of the i th ecosystem service observed; and $ES_{i,max}$, $ES_{i,min}$ are the maximum and minimum values of the ith ecosystem service, respectively.

$$RMSE = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(ES_{i,std} - \overline{ES})^2} \quad \text{(S10)}$$

where $ES_{i,std}$ is the normalized value of any ecosystem and $\overline{ES}$ is the *i* th standard ecosystem service. In both dimensions, the root mean square error (RMSE) denotes the distance between the coordinates and the diagonal. The relative position on a geographic scale indicates the relative benefit of an ecosystem-side service. The procedure for performing the computation in detail can be found in the literature [45]. The root mean square error estimates the average difference in standard deviation between the individual ecosystem service's standard deviation and the standard deviation of all ecosystem services. This indicates the most favorable ecosystem service and shows the regional variance in the rate of change of ecosystem services. Additionally, the trade-offs/synergies between ecosystem services are more thorough when analyzed in this manner.

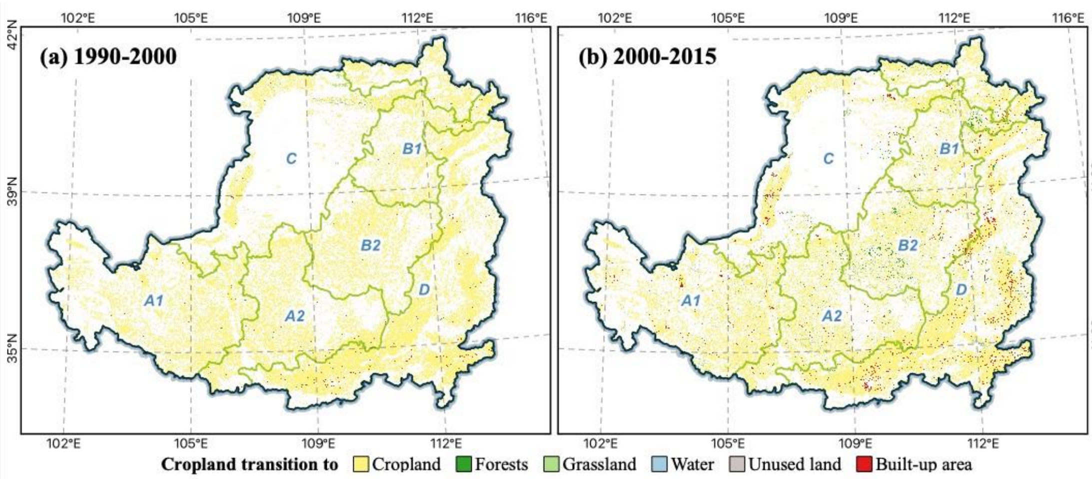

Figure S1. Cropland use/cover change in the LP, 1990-2000 (a), 2000-2015 (b)

Table S1 Land use transfer matrix in the LP, 1990-2000, 2000-2015 (Unit: km^2)

Classification		**2000**						
		Cropland	**Forest**	**Grassland**	**Water**	**Unused land**	**Built-up land**	**Total area**
1990	Cropland	211034.00	197.65	4094.05	445.70	393.09	4.64	216169.13
	Forest	294.48	94422.40	643.59	19.66	104.24	1.68	95486.04
	Grassland	1286.08	881.87	264505.00	131.46	2220.70	1.61	269026.72
	Water	205.30	11.31	219.16	8639.62	99.61	0.18	9175.18
	Unused land	358.97	55.51	1276.40	84.64	41557.10	0.11	43332.72
	Built-up land	1043.81	30.75	155.84	6.29	18.85	14839.40	16094.95
	Total area	214222.65	95599.49	270894.03	9327.37	44393.58	14847.61	649284.74
	Gap between 2000 and 1990	-1946.48	113.45	1867.32	152.19	1060.86	-1247.33	
Classification		**2015**						

		Cropland	Forest	Grassland	Water	Unused land	Built-up land	Total area
	Cropland	195729.00	972.06	7562.51	722.24	1226.14	1435.61	207647.55
	Forest	3189.05	91968.10	3187.69	75.41	173.56	48.62	98642.43
	Grassland	9364.38	1656.37	252843.00	460.69	4272.34	247.24	268844.01
2000	Water	760.18	102.31	411.73	7309.57	315.88	47.03	8946.70
	Unused land	541.81	268.43	2565.68	395.53	36899.90	21.22	40692.57
	Built-up land	6584.85	518.02	2456.44	211.76	444.09	14294.90	24510.06
	Total area	216169.27	95485.29	269027.05	9175.20	43331.91	16094.62	649283.33
	Gap between 2015 and 2000	8521.72	-3157.14	183.03	228.50	2639.34	-8415.44	

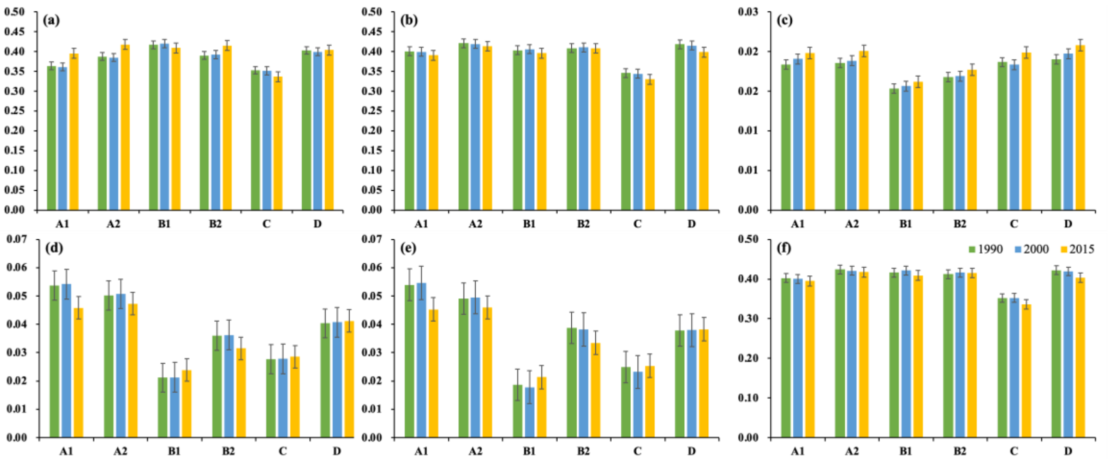

Figure S2. Trade-offs/synergies change between ecosystem services in the LP, 1990, 2000 and 2015. Note: (a) HQ & SC; (b) CS & HQ; (c) CS & WY; (d) CS & SC; (e) SC & WY; (f) HQ & WY.

Table S2 The power of q for the 6 factors explaining the trade-offs/synergies between ecosystem services in the LP, 2015

Driving factors		**DEM**	**GDP**	**NDVI**	**PER**	**PET**	**POP**
CS & HQ	*q*	0.114**	0.003	0.005	0.004	0.005	0.005

CS & SC	*q*	0.034**	0.004	0.028**	0.041**	0.007	0.029**
CS & WY	*q*	0.009**	0.007	0.003	0.003	0.003	0.003
HQ & SC	*q*	0.123**	0.004	0.011**	0.028**	0.005	0.014**
HQ & WY	*q*	0.122**	0.004	0.006	0.007	0.006	0.006
SC & WY	*q*	0.037**	0.003	0.024**	0.043**	0.008	0.032**

Table S3 Interaction detection between ecosystem services in the LP, 2015

Pair of ecosystem services	**Dominant factor**	**q**	**Dominant interaction factor**	**q**
CS & HQ	DEM	0.114	(PER)∩(CS & HQ)	0.1471
CS & SC	PER	0.041	(DEM)∩(CS & SC)	0.0705
CS & WY	DEM	0.009	(PER)∩(CS & WY)	0.0259
HQ & SC	PER	0.028	(NDVI)∩(HQ & SC)	0.0461
HQ & WY	DEM	0.122	(DEM)∩(HQ & WY)	0.1502
SC & WY	PER	0.043	(DEM)∩(SC & WY)	0.0787