Supplementary

Model calibration and validation

The key to model calibration is to obtain accurate model parameters. This paper refers to previous WRB [1] and Yellow River Basin [2] studies to determine the parameters needed to run the model such as biophysical coefficient table (Table S1) and seasonal constant Z (set to 8 after several corrections).

Table S1. The biophysical coefficients table

Code	Land-use type	Vegetated type	Root depth (mm)	Kc
1	Forest	1	5200	1
2	Cropland	1	2000	0.65
3	Built_up land	0	0.00	0.3
4	Grassland	1	2400	0.65
5	Water	0	100	1
6	Barren land	0	100	0.2

In column "Vegetated type", "1" denotes vegetated land-use type and "0" denotes non-vegetated land-use type; Kc is evapotranspiration coefficient

The natural river runoff data observed in the Wei River Basin from 2000 to 2020 are obtained from the Shaanxi Provincial Water Resources Bulletin, the Gansu Provincial Water Resources Bulletin and the Ningxia Autonomous Region Water Resources Bulletin. The accuracy of the hydrological module of the InVEST model was tested by comparing the measured values with the simulated values. The model performance was examined using Nash–Sutcliffe efficiency coefficient (NSE), coefficient of determination (R^2), and root mean square error (RMSE). The results show that NSE = 0.681, R^2 = 0.8372 and RMSE = 10.81, indicating that InVEST has good applicability in the WRB

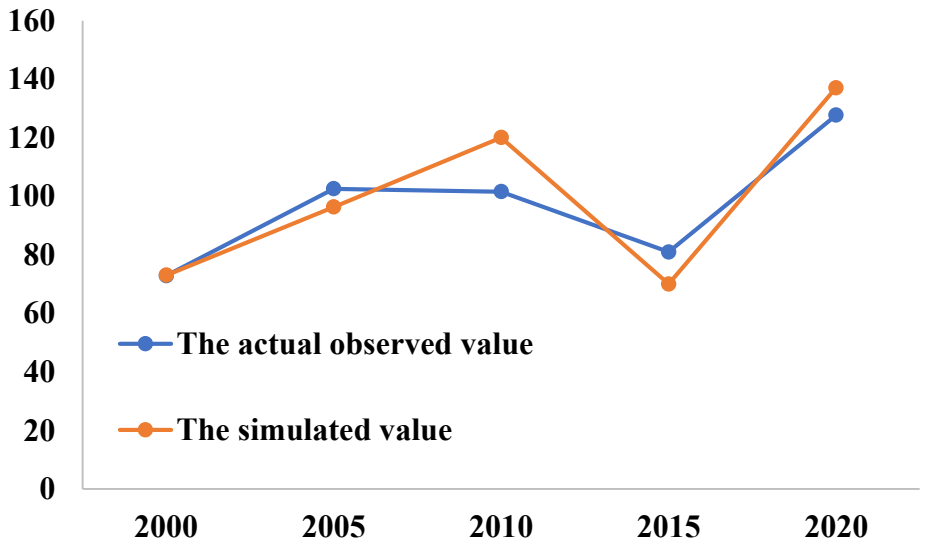

Figure S1. Comparison and validation diagram of model simulation value and observed value

Data sources

Spatial trends show the greatest increase in precipitation in the upper Wei River (>7 mm/a) and a decrease in precipitation in both the northern and southern Wei River (> -0.5 mm/a). Temperatures in the Wei River basin have remained stable overall, with most areas increasing by 0.01-0.5℃/a, however, in places such as the Beiluo River, there has been a significant decrease in temperature.

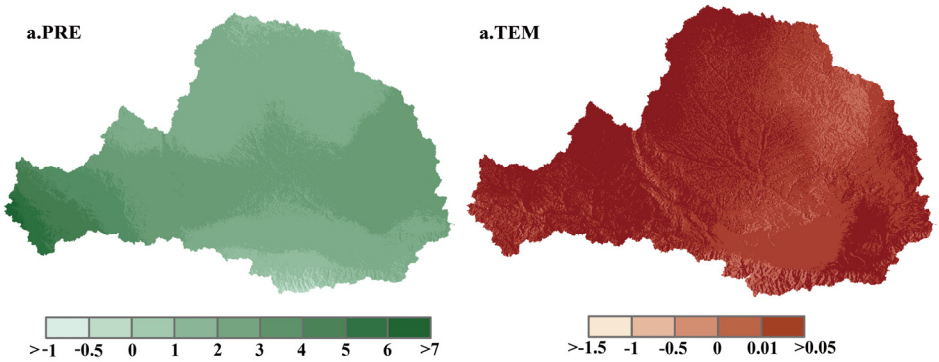

Figure S2. The slopes of changes in precipitation and temperature from 2000-2020.

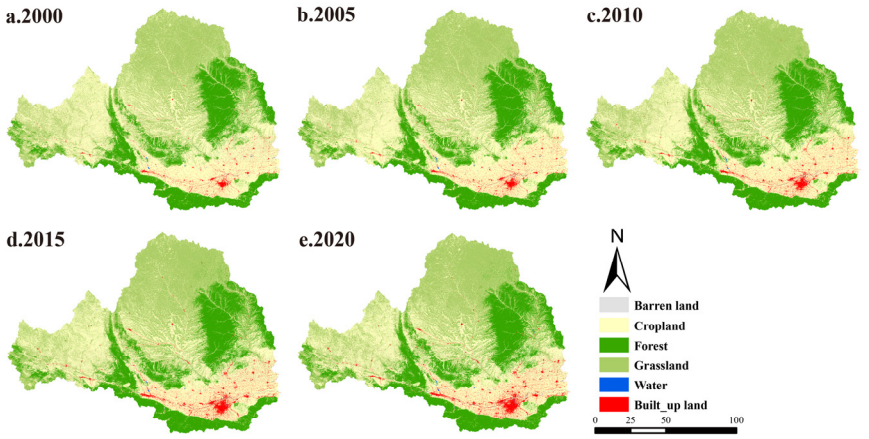

Figure S3. Land-cover types in the Wei River Basin from 2000 to 2020.

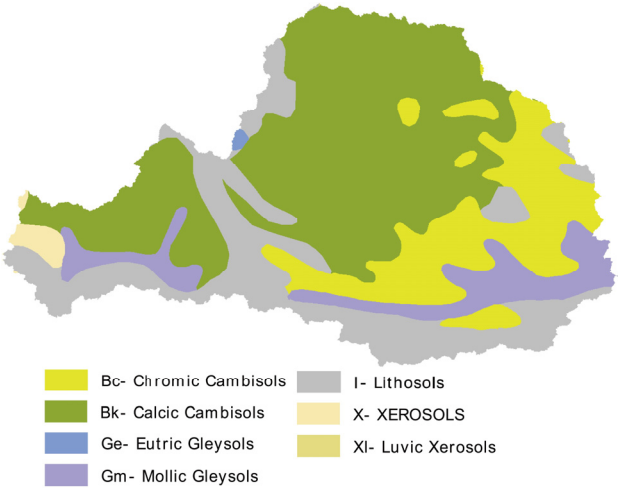

Figure S4. Soil types in the Wei River Basin.

Correlation Analysis

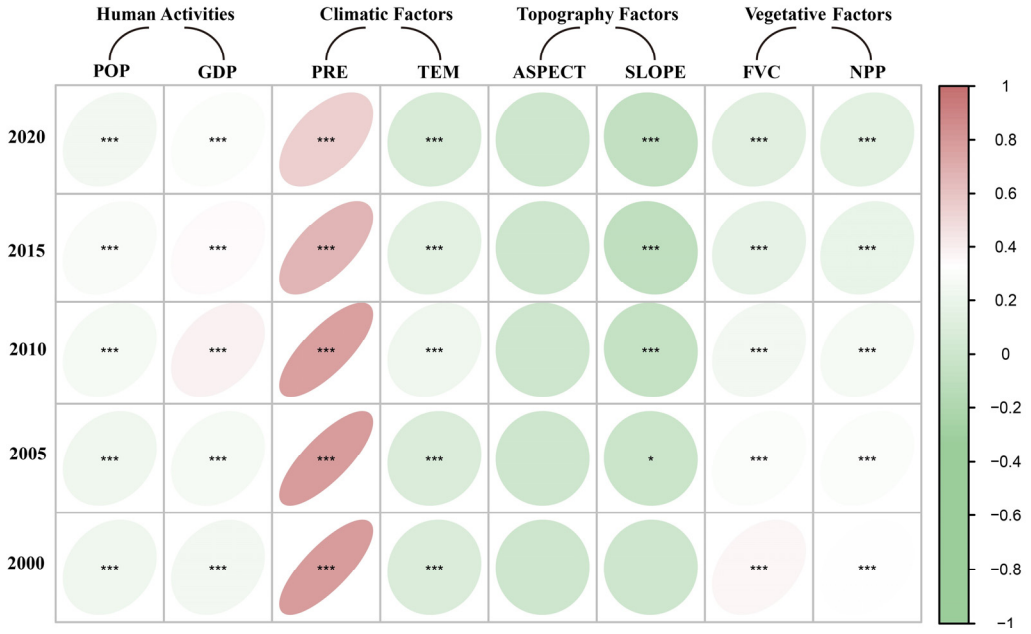

Figure S5. Correlations of WYs in 2000-2020 with driving factors. Pearson correlation is shown in a color gradient (***, $p < 0.001$; **, $p < 0.01$; *, $p < 0.05$).

The Pearson correlation coefficient is a popular statistic that is used to quantify the linear correlation between two variables on a global scale. The determination of Pearson's correlation coefficient values indicates that the WYs is significantly correlated with the influencing factors (except for topographic factors). For human activities, there is a considerable positive correlation between POP, GDP, and WYs, and this association has intensified over time (Figure 5), showing that anthropogenic activities and urbanization are exerting a growing effect on WYs. During the period 2000-2020, the factor with the greatest influence on WYs has been precipitation, showing a greatly positive linear relationship with WYs ($P < 0.001$ and correlation coefficients greater than 0.7), but the correlation coefficient for precipitation has gradually decreased over time. Moreover,

it was discovered that the SLOPE factors had typically unfavorable effects on WYs, notably for 2010 to 2020, with correlation coefficients above 0.3. In contrast to human activities, the vegetation factor decreases in relevance over time with each year. This may be due to the massive urbanization of the Guanzhong Basin and the reduction in vegetation cover.

Table S2. Multicollinearity test between driving variables. Take the year 2000.

driving variables	SD	VIF
GDP density (GDP)	0.000403	1.408024
Population density (POP)	0.000165	1.292318
Annual precipitation	0.001957	2.191367
Annual temperature	0.070650	1.349889
Slope	0.001435	1.001093
Aspect	0.016049	1.135011
FVC	1.056014	2.479634
NPP	0.001972	2.429140

Table S3. Moran's I of the residuals of the MGWR, GWR, and OLS models.

	Moran's IM	Moran's IG	Moran's IO
2000	-0.010999	0.008677	0.281919
2005	-0.003064	0.000525	0.318348
2010	-0.007399	0.000779	0.201096
2015	-0.016101	-0.016534	0.198058
2020	-0.023423	-0.023465	0.200213

"Moran's IM" denotes the Moran's I of residuals of MGWR model; "Moran's IG" denotes the Moran's I of residuals of GWR model; "Moran's IO" denotes the Moran's I of residuals of OLS model.

References

1. Wu, C., Qiu, D., Gao, P., Mu, X.,Zhao, G. Application of the InVEST model for assessing water yield and its response to precipitation and land use in the Weihe River Basin, China. *Journal of Arid Land* **2022**, *14*, 426-440.
2. Yang, J., Xie, B.P.,Zhang, D.G. Spatio-temporal variation of water yield and its response to precipitation and land use change in the Yellow River Basin based on InVEST model. *The Journal of Applied Ecology* **2020**, *31*, 2731-2739 (in chinese).