1. HAII

$$HAII = \frac{S_{CLE}}{S} \times 100\% \quad (1)$$

$$S_{CLE} = \sum_{i=1}^{n} (SL_i \cdot CI_i) \quad (2)$$

HAII is the human activity intensity of land surface; $S_{CLE}$ is the area of construction land equivalent (CLE); S is the total area of the region; $SL_i$ is the area of the ith land use/cover type; $CI_i$ is the coefficient of CLE for the ith land use/cover type; n is the number of land use/cover types in the region. Construction land equivalent (CLE) is a unit of measurement as reflected by land use/cover types used to compare the impact of different human activities on the land surface. In order to uniformly measure the degree of HAILS, it is stipulated that the land use/cover type with the highest degree of human activities on the land surface - construction land equivalent- is the basic unit of measurement. There are 9 land use types, among which the CI value of cropland is 0.2, the CI value of forest, shrub, water, barren, snow and wetland areas is 0, and the CI value of impervious areas is 1 [67].

2. QCI and PCI

The QCI[22,65] is used to quantify the seasonal variation of Q and is calculated as:

$$QCI = \sum_{i=1}^{12} q_i^2 / (\sum_{i=}^{12} q_i)^2 \times 100 \quad (3)$$

The Q indices have been widely used in the literature to assess Q seasonality characteristics under global change[68,69]. To account for the influence of changing precipitation, we similarly calculated the corresponding indices for precipitation (PCI) in the same way.

3.Factors Explanation

Table S1 Detailed information on eight driving factors

| ID | Factors | Original spatial resolution(°) | Resampling(°) | Original temporal resolution | Temporal resolution adopted |
|---|---|---|---|---|---|
| $X_1$ | QCI | 0.25 | 0.25 | Month | multi - year average |
| $X_2$ | PCI | 0.1 | 0.25 | Month | multi - year average |
| $X_3$ | HAII | 0.05 | 0.25 | Year | multi - year average |

| | | | | | |
|---|---|---|---|---|---|
| $X_4$ | DEM | 0.04 | 0.25 | - | - |
| $X_5$ | Slope | 0.04 | 0.25 | - | - |
| $X_6$ | Soil Moisture | 0.25 | 0.25 | Month | multi - year average |
| $X_7$ | Snow Fraction | 0.1 | 0.25 | Month | multi - year average |
| $X_8$ | Curvature | 0.04 | 0.25 | - | - |

## 4. Dominance analysis

Dominance analysis (DA) is designed to determine the degree to which different explanatory variables contribute to the coefficient of determination $R^2$ in a linear regression. Luchman points out[22]:D A has three dominant types: complete dominance, conditional dominance and general dominance.

To model fit across every possible comparison of other independent variables included or excluded from estimation , complete dominance is used by comparing the marginal contribution of two independent variables. Complete dominance is designated for p independent variables using the $R^2$ by

$$X_v DX_z if\, 2^{p-2} = \sum_{j=1}^{2^{p-2}} \begin{cases} if\ R^2_{X_v S2_j} - R^2_{S2_j} > R^2_{X_z S2_j} - R^2_{S2_j}\ then\ 1 \\ f\ R^2_{X_v S2_j} - R^2_{S2_j} \le R^2_{X_z S2_j} - R^2_{S2_j}\ then\ 0 \end{cases} \quad (1)$$

where $X_vDX_z$ indicates that $X_v$ completely dominates $X_z$ and $S2_j$ is a distinct subset of the $p-2$ independent variables that excludes both $X_v$ and $X_z$, which can include the null set of no other independent variables. $R^2_{X_v S2_j}$ is the $R^2$ for the distinct subset of variables $S2_j$ , which also includes $X_v$ but not $X_z$, and $R^2_{S2_j}$ is the $R^2$ for the same distinct subset of variables $S2_j$ , which excludes both $X_v$ and $X_z$. Complete dominance is then designated if, across all $2^{p-2}$ subsets $S2_j$ , adding $X_v$ results in a larger increment to the fit statistic (that is, $R^2$)than adding $X_z$.

Conditional dominance begins by averaging the marginal contributions to the fit statistic attributable to an independent variable within an order—where order refers to the number of independent variables in the model. When considering independent variable $X_v$, for models with i of the p possible independent variables included, the within-order average for variable $X_v$ will be

$$C_{X_v}^{i} = \sum_{l-1}^{\binom{p-1}{i-1}} \frac{R^2_{X_v S_l} - R^2_{S_l}}{\binom{p-1}{i-1}} \quad (2)$$

where $S_l$ is a distinct subset of $i-1$ IVs that excludes $X_v$, which can include the null set of no *IV*s, and independent variables *and* $\binom{p-1}{i-1}$ is the number of distinct combinations of the size of the bottom number (that is, $i-1$) out of the number of elements of the size of the top number (that is, $p-1$). Each independent variables' contributions to model fit can be compared by conditional dominance statistic as well as a second level of relative importance determined[70].

General dominance involves taking the conditional dominance statistics and further averaging them between orders for each independent variable. For the $p$ within-order averages or conditional dominance statistics associated with $X_v$, the between-order average is

$$C_{X_v} = \sum_{i=1}^{p} \frac{C_{X_v}^{i}}{p} \quad (3)$$

General dominance for $X_v$ over $X_z$ is determined when the general dominance statistic for $X_v$ is bigger than that for $X_z$.

These three dominance types can be gotten by Stata-based DA model[70].

Table S2 General dominance statistics

| | Dominance | Standardizad | Ranking |
|---|---|---|---|
| Landuse of Grassland | 0.1488 | 0.5946 | 1 |
| Landuse of Impervious | 0.046 | 0.184 | 2 |
| Wateruse of Industrail | 0.0179 | 0.0715 | 3 |
| Wateruse of Domestic | 0.0161 | 0.0642 | 4 |
| Wateruse of Agricultural | 0.0138 | 0.0552 | 5 |
| Landuse of Agricultural | 0.0076 | 0.0306 | 6 |