Supplementary materials

Note S1. CSLE model to assess soil erosion

The Chinese Soil Loss Equation (CSLE) is used to assess the soil erosion modulus of cropland in China in 2020. The formula for the CSLE is Eq. (1) (Liu et al., 2020).

$$A = R \cdot K \cdot L \cdot S \cdot B \cdot E \cdot T \tag{1}$$

Where A is soil loss (t/(hm^2 • yr)). R is rainfall erosivity (MJ • mm/(hm^2 • h • yr)). K is soil erodibility (t • hm^2 • h/(hm^2 • MJ • mm)). L is the dimensionless slope length factor. S is the dimensionless slope steepness factor. B is the dimensionless vegetation cover and biological practice factor. E is the dimensionless soil and water conservation engineering practices factor. T is the dimensionless tillage and management factor.

Calculation of *R-factor*. Daily rainfall data from 2,417 meteorological stations across mainland China, covering the period from 1991 to 2020, were used to calculate the average annual rainfall erosivity. The calculated values from meteorological stations were interpolated into raster layers with the ordinary kriging method. The rainfall erosivity was calculated using the modified algorithm by Xie et al. (2016), which is as follows:

$$\bar{R} = \sum_{k=1}^{24} \bar{R}_{hmk} \tag{2}$$

$$\bar{R}_{hmk} = \frac{1}{n} \sum_{i=1}^{n} \sum_{j=0}^{m} \left(\alpha \cdot p_{i,j,k}^{1.7265}\right) \tag{3}$$

$$\overline{WR}_{hmk} = \frac{\bar{R}_{hmk}}{\bar{R}} \tag{4}$$

where $\bar{R}$ is average annual rainfall erosivity (MJ • mm/(hm^2 • h • yr)), k represents the sequence of half-months in each year, $\bar{R}_{hmk}$ is the rainfall erosivity of the k-th half month within each year (MJ • mm/(hm^2 • h • yr)), n is the number of years (from 1991 to 2020), j is the days of daily erosive rainfall within each half month. The daily erosive rainfall is defined as daily rainfall that is greater than or equal to 12 mm (Xie et al., 2002). The α was set to 0.3957 for warm months from May to September and 0.3103 in remaining months. $\overline{WR}_{hmk}$ is the proportion of the rainfall erosivity in the k-th half month to the average annual rainfall erosivity.

Calculation of *K-factor*. The K-factor was obtained from the Center for Geodata and Analysis, Faculty of Geographical Science, Beijing Normal University (https://gda.bnu.edu.cn).

Calculation of *LS-factor*. The LS-factor includes the L-factor and the S-factor, which were calculated based on NASADEM data. The NASADEM data can be accessed at the Land Processes Distributed Active Archive Center (https://lpdaac.usgs.gov/products/nasadem_hgtv001/). The S-factor was calculated using segmented calculations for slope less than or equal to 10° based on the method proposed by Wischmeier and Smith (1978), and for slope greater than 10° using the method proposed by Liu et al. (1994).

$$S = \begin{cases} 10.8sin\theta + 0.03 & \theta \leq 5° \\ 16.8sin\theta - 0.50 & 5° < \theta \leq 10° \\ 21.9sin\theta - 0.96 & \theta > 10° \end{cases} \tag{5}$$

The L-factor was calculated according to the algorithm developed by Foster and Wischmeier (1974).

$$L_i = \frac{\lambda_{out}^{m+1} - \lambda_{in}^{m-1}}{(\lambda_{out} - \lambda_{in}) \times 22.13^m} \tag{6}$$

where L_i is the slope length factor, λ_{out} and λ_{in} slope length for segment *i* and segment *i-1* in m, respectively. The slope length index (m) was calculated using the modified algorithm proposed by Liu et al. (2000).

$$m = \begin{cases} 0.2 & \theta \leq 1° \\ 0.3 & 1° < \theta \leq 3° \\ 0.4 & 3° < \theta \leq 5° \\ 0.5 & \theta > 5° \end{cases} \tag{7}$$

Calculation of *B-factor*. The B-factor for cropland was set to 1 (Liu et al., 2020).

Calculation of *T-factor*. The T-factor was calculated based on the China crop rotation map (Liu and Han, 1987). China was divided into three zones, with 12 primary subzones and 38 secondary subzones. Each cropping area zone assigned a specific T factor value (Soil and Water Conservation Monitoring Center and Ministry of Water Resources, 2018).

Note S2. Calculation of soil erosion area

The soil loss tolerance in different erosion type zones is different. Based on the soil loss tolerance established by the standards for classification and gradation of soil erosion (Ministry of Water Resources of the People's Republic of China, 2008) (Table S4), the soil erosion area for each region is calculated individually. Finally, the erosion area of cropland is aggregated to derive the total erosion area.

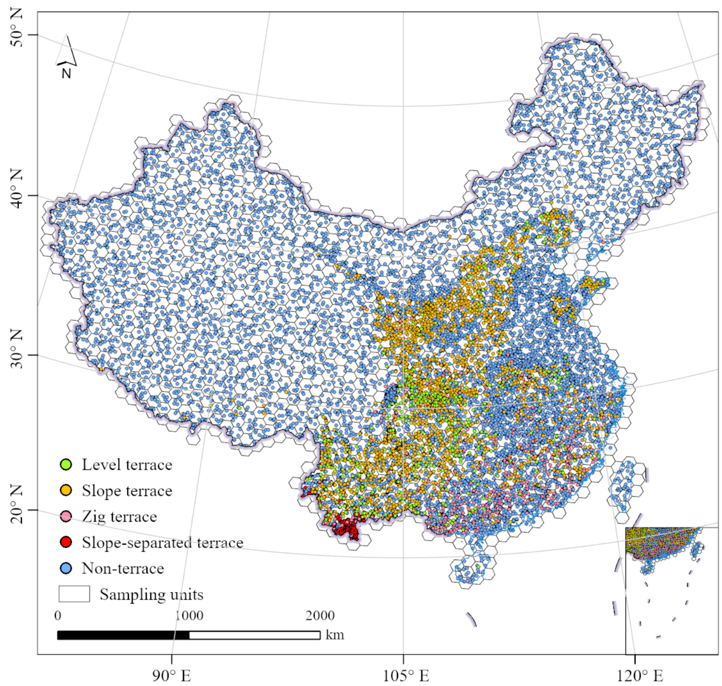

Figure S1. The spatial distribution of train samples (taking the year 2010 as an example).

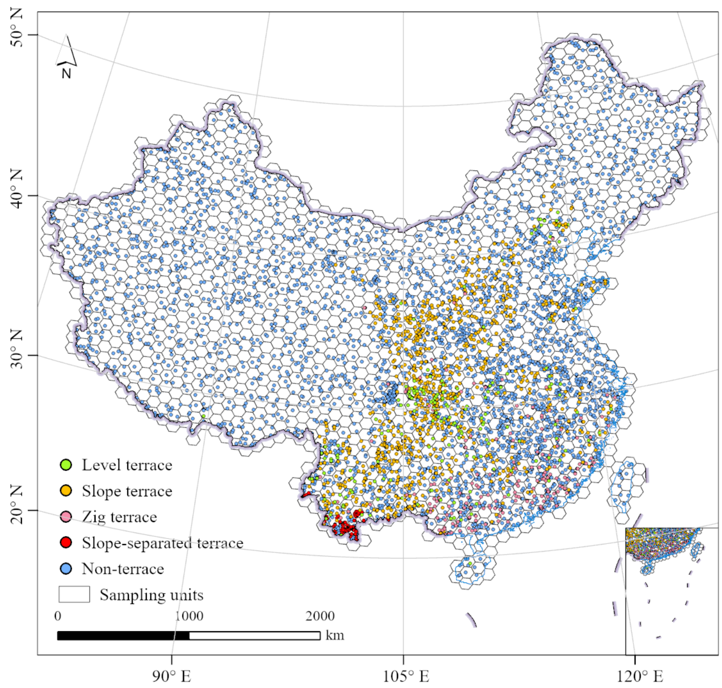

Figure S2. The spatial distribution of validation samples (taking the year 2010 as an example).

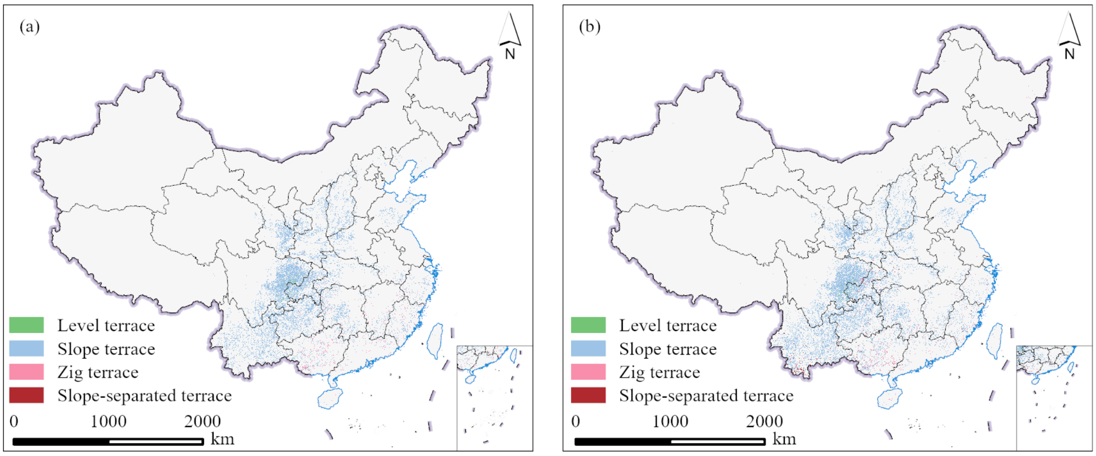

Figure S3. The spatial distribution of terraces from 2000 to 2010. (a) The spatial distribution of terraces in 2000. (b) The spatial distribution of terraces in 2010.

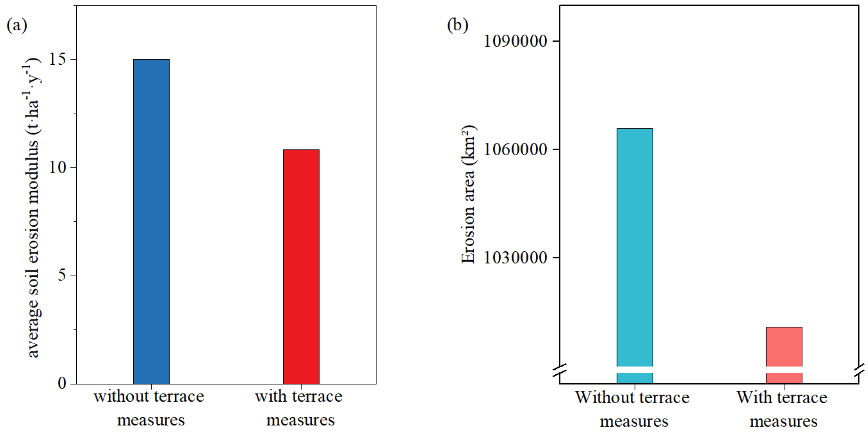

Figure S4. Comparison of soil erosion modulus and soil erosion areas in different scenarios. (a) Comparison of soil erosion modulus with and without terrace measures. (b) Comparison of soil erosion areas with and without terrace measures.

Table S1. The multitemporal data series used in this study.

Data name	Year	Spatial resolution (m)	Data sources
Landsat-4/5/7/8 surface reflectance (SR) data	2000, 2010, 2020	30	The data is accessible via GEE and is provided by the United States Geological Survey (USGS) (https://earthengine.google.com/).
SRTM DEM	2000	30	The data is accessible via GEE and is provided by The National Aeronautics and Space Administration (NASA)/USGS/Jet Propulsion Laboratory (JPL) (https://earthengine.google.com/).
GlobeLand30	2000, 2010, 2020	30	The data is provided by the National Geomatics Center of China (NGCC) (http://www.globallandcover.com/).

Table S2. Input features of multi-temporal metrics each year used for SWCTMD mapping.

Category	Feature	Description	Data source
Spectrum	25th, 50th, and 75th percent quantiles of Landsat SR bands (red, green, blue, near-infrared, shortwave infrared 1, and shortwave infrared 2)	Spectral bands of Landsat SR	Landsat
Spectral indices	25th, 50th, and 75th percent quantiles of NDVI, MNDWI, NDBI, BSI, LSWI, EVI	Normalized indices derived from Landsat SR spectral bands are calculated as: $\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + \mathrm{Red})}$ $\mathrm{MNDWI} = \frac{(\mathrm{Green} - \mathrm{SWIR1})}{(\mathrm{Green} + \mathrm{SWIR1})}$ $\mathrm{NDBI} = \frac{(\mathrm{SWIR1} - \mathrm{NIR})}{(\mathrm{SWIR1} + \mathrm{NIR})}$ $\mathrm{BSI} = \frac{((\mathrm{SWIR1} + \mathrm{Red}) - (\mathrm{Blue} + \mathrm{NIR}))}{((\mathrm{SWIR1} + \mathrm{Red}) + (\mathrm{Blue} + \mathrm{NIR}))}$ $\mathrm{LSWI} = \frac{(\mathrm{NIR} - \mathrm{SWIR1})}{(\mathrm{NIR} + \mathrm{SWIR1})}$ $\mathrm{EVI} = \frac{2.5 * (\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + 6 * \mathrm{Red} - 7.5 * \mathrm{Blue} + 1)}$	Landsat
Texture	ASM, Entropy, Contrast, Correlation for 25th, 50th, and 75th percent quantiles of near-infrared band	Texture features were calculated using the built-in Grey Level Co-occurrence Matrix texture (GLCM) functions available on the Google Earth Engine (GEE) platform.	Landsat
Topography	Elevation, slope, aspect, Slope of slope, roughness, slope shape, relief	Texture features derived from SRTM DEM data are calculated as: Elevation, aspect and slope were calculated using the built-in terrain functions available on the GEE platform. $\text{Slope of slope} = \frac{\text{Slope change}}{\text{Horizontal distance change}}$ $\text{Roughness} = \frac{\text{Curved surface area}}{\text{Plan surface area}}$ $\text{Slope Shape} = H_{i,j} - \frac{\sum_{i=1}^{n} H_i}{n}$ $\text{Relief} = \mathrm{H_{max}} - \mathrm{H_{min}}$	SRTM DEM

Table S3. Samples collected from 2000 to 2010.

Type	2000	2010	2020
Level terrace	545	558	520
Slope terrace	2687	2687	2675
Zig terrace	574	588	593
Slope-separated terrace	271	271	269
Non-terrace	11394	11392	11542
Total	17392	17417	17520

Table S4. Soil erosion intensity classification standard.

Level	**Soil erosion modulus ($t \cdot ha^{-2} \cdot yr^{-1}$)**
Slight (No erosion)	<2, <5, <10
Low	2, 5, 10 ~ 25
Moderate	25 ~ 50
Hight	50 ~ 80
Extremely high	80 ~ 150
Severe	>150

Note: Northwest Loess Plateau < 10, Southern Red Soil Hilly zone/Southwestern Stony Mountain area < 5, Northeast Black Soil zone/Northern Stony Mountain area < 2.

Supplementary references

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