land

Supplementary Materials

File 1 Evaluation of Net Soil Carbon Erosion (C_{loss})

1.1 WaTEM/SEDEM Model

1.1.1 Net Soil Erosion

The water and tillage erosion model and sediment delivery model (WaTEM/SEDEM) were utilized to simulate the net soil loss within the study area [36,37,39]. This model is renowned for its application in hydraulic erosion assessment across watersheds, regions, and basins [23,38–41] and encompasses two integral components [37,38].

Initially, soil loss estimation was performed following the multi-parameter scheme of the revised universal soil loss equation (RUSLE; see Equation (S1)).

$$SL = RKLS_{2D}CP \quad (S1)$$

where SL is the mean soil loss ($t \cdot ha^{-1} \cdot yr^{-1}$), which is the product of the rainfall intensity factor R ($MJ \cdot mm \cdot ha^{-1} \cdot h^{-1} \cdot yr^{-1}$), the soil erodibility factor K ($t\ h\ MJ^{-1}\ mm^{-1}$), the two-dimensional slope and slope length factor LS_{2D}, the cover management factor C (dimensionless), and the conservation support practice factor P (dimensionless).

Then, the sediment transport capacity (T, $kg \cdot m^{-2} \cdot yr^{-1}$) was calculated using the equation proposed by Verstraeten et al. [37]:

$$TC = K_T RK(LS_{2D} - 4.1S^{0.8}) \quad (S2)$$

where TC is the transport capacity ($kg \cdot m^{-2} \cdot yr^{-1}$), and K_t (m) is the transport capacity coefficient, which reflects the influence of the surface vegetation cover on the sand transport capacity, where the higher the surface vegetation cover, the lower the K_t value. The variables R, K, and LS_{2D} are the

RUSLE input factors (Equation (S1)).

Finally, the model underwent parameterization and calibration. The Kt coefficients' maximum and minimum values were calibrated using sand transport data measured from 2003 to 2008 at the Xiaohuangguayuan Hydrological Station in Yuanmou County (Figure 1B). Simulated sand production values within the study area were compared against measured values to calibrate the sand transport capacity coefficient. The calibration process involved assessing the model's efficiency via the Nash efficiency coefficient (NS) [37] and quantifying the prediction error using the root mean square error (RMSE). The NS coefficient evaluates the model efficiency, while the RMSE gauges the prediction accuracy, computed using the following formulas:

$$NS = 1 - \frac{\sum_{i=1}^{n}(O_i - P_i)^2}{\sum_{i=1}^{n}(O_i - O_{mean})^2} \quad \text{(S3)}$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)^2} \quad \text{(S4)}$$

where n is the number of calibrated catchments, O_i is the observed value, P_i is the simulated value, and O_{mean} is the mean observed value. The closer the NSE is to one, the more efficient the model. The closer the RMSE is to zero, the better the model performance.

1.1.2 Detachment of Carbon via Erosion

The soil loss rates modeled with WaTEM/SEDEM were used to quantify the net soil carbon removed via erosion (C_{loss}; Equation (S5)) [35]:

$$C_{loss} = TC \cdot (SL/(BD \cdot SD \cdot 100)) \quad \text{(S5)}$$

where TC is the soil carbon content of the spatially explicit topsoil layer (kg m^{-2} in the 0–20 cm layer), SL is net soil loss estimated using WaTEM/SEDEM (kg m^{-2} yr^{-1}), BD is the soil bulk density (kg m^{-3}), and SD is the surface layer depth (20 cm).

File 2 Evaluation of Net Change in Soil Carbon Pool (ΔC)

2.1 Soil Sample Analysis

The difference between the TC and SOC contents was calculated per the principle of mass conservation to determine the soil inorganic carbon (SIC) content (Figure S1).

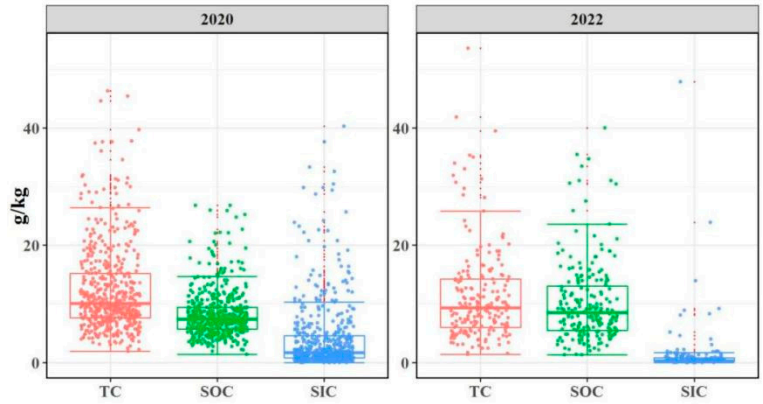


Figure S1. Detection results of the soil total carbon (TC), soil organic carbon (SOC), and soil inorganic carbon (SIC) contents.

2.2 Net Change in Soil Carbon Pool (ΔC)

The carbon content of each soil type was individually tallied, and the change in the annual average soil carbon pool was subsequently computed [43–46].

$$C_i = \sum_{i=1}^{n} BD_i \times N_i \times T_i / 10 \times SD_i \qquad (S6)$$

$$\Delta C = \frac{\sum C_{ia} - \sum C_{ib}}{a - b} \quad (a > b) \qquad (S7)$$

where C_i is the carbon content of the soil types, BD_i is the soil bulk density, N_i is the soil carbon content, T_i is the depth of the mapped layer, SD_i is the area of the soil type distribution, and a and b are years.