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# Soil erosion of sediment sources and their impact factors in a check dam control watershed on the Loess Plateau of China

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# Introduction

- Soil erosion is a severe environmental problem in the Loess Plateau.
- Soil erosion causes several problems:

(1) Soil fertility declines

(2) Soil loess

(3) Broken terrain ...

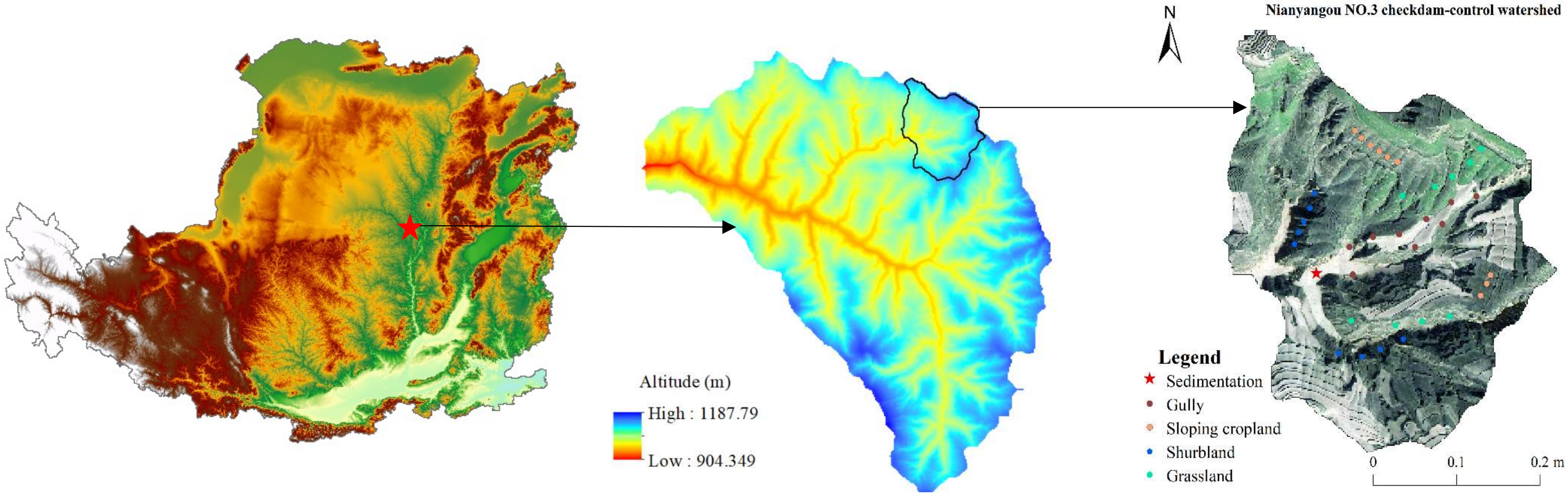


# Introduction

- Quantitative analysis of sediment sources is crucial for soil erosion control.
- Compared with the other soil and water conservation measures, the dam land sedimentation by check dam provided an information for studying historical sediment sources.



# Material and methods




- The Nianyangou watershed is located in the middle of the Loess Plateau.
- The check dam (no drainage structure) controlled subwatershed was therefore selected for sampling.
- The main land use types in the study area are sloping cropland, grassland, and shrubland.

# Material and methods


- Sediment core samples: A sediment core with a depth of 5.98 m was collected and it was divided into 29 layers.
- Sediment source samples: Four sources including sloping cropland, grassland, shrubland on the slope, and gully were selected for surface soil samples (0–5 cm) collecting. A total of 36 soil samples from the sediment sources samples were collected.

# Material and methods

Collins mixing model:

$$R_{es} = \sum_{i=1}^{n} \left[ \frac{C_i - (\sum_{s=1}^{m} C_{si} P_s)}{C_i} \right]^2 \quad (1)$$

$$GOF = \left( 1 - \frac{1}{n} \sum_{i=1}^{n} \frac{C_i - \sum_{s=1}^{m} P_s C_{si}}{C_i} \right) \times 100\% \quad (2)$$

$$0 \leq Ps \leq 1 \quad (3)$$

$$\sum_{s=1}^{n} p_s = 1 \quad (4)$$

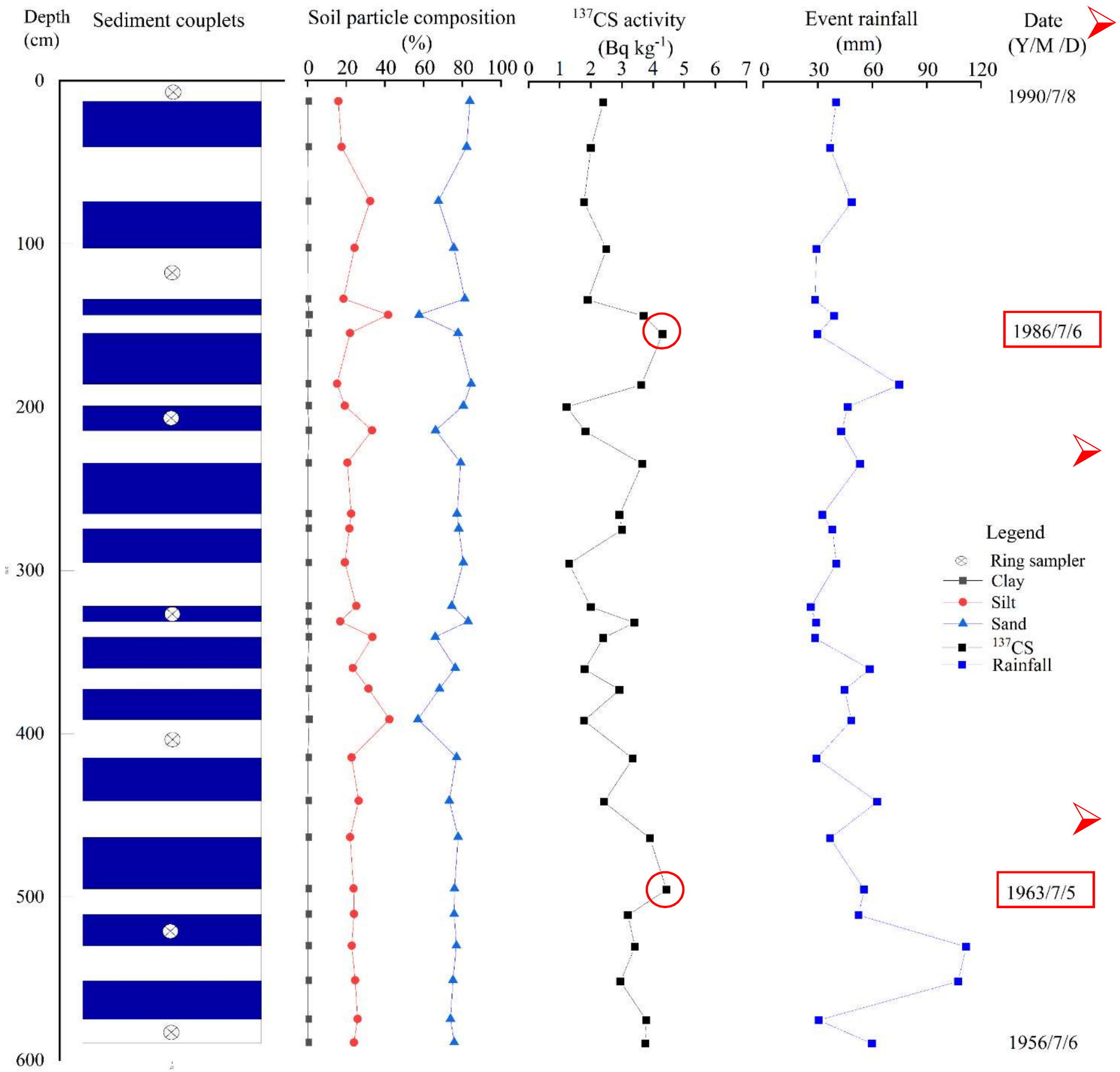
The sediment source was calculated by Collins mixing model:

The sediment source results were calculated according to equation (1).

The goodness of fit of the mixed model was calculated using equation (2).

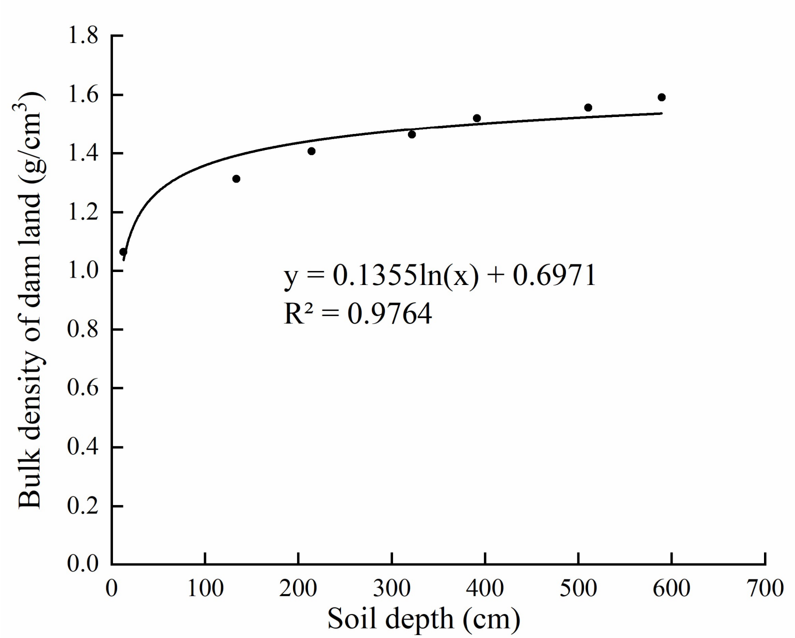
Equations (3) and (4) are the limiting conditions.

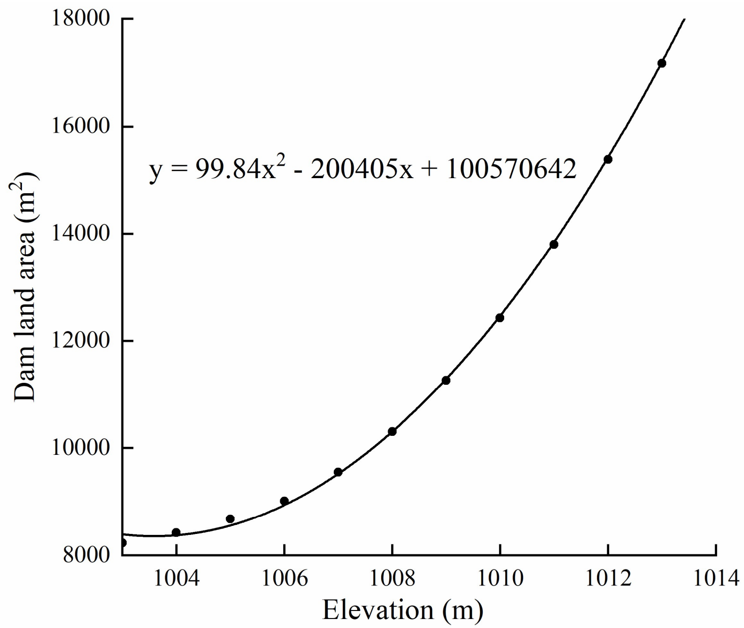
# Results

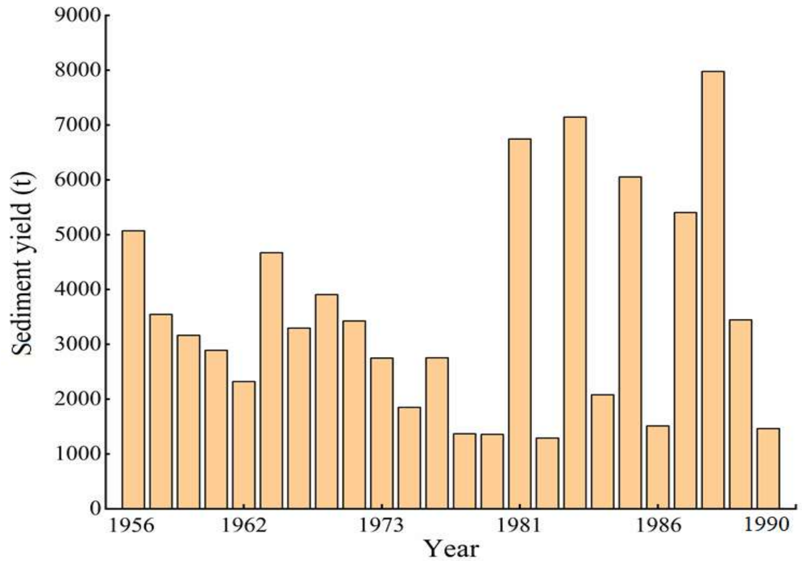



- **The thickness of the sediment core was different:** The thickest sedimentation was found in the 3rd layer with 33.2 cm. The thinnest sedimentation was the 6th layer with 11.2 cm.
- **Average soil particle composition:** sand (75.20%), silt (24.53%), clay (0.27%).CV values were 0.31, 0.21 and 0.10, respectively.
- **$^{137}$Cs activity: The highest in the 24th layer** ($4.43 Bq \cdot Kg^{-1}$);The second highest in the 7th layer ($4.27 Bq \cdot Kg^{-1}$)

# Results




- The total sediment yields in the dam land was 77,430 t.
- The highest sediment yield was in the 7th layer(4465 t).
- The lowest sediment yield was in the 13th layer(1230 t).

# Results

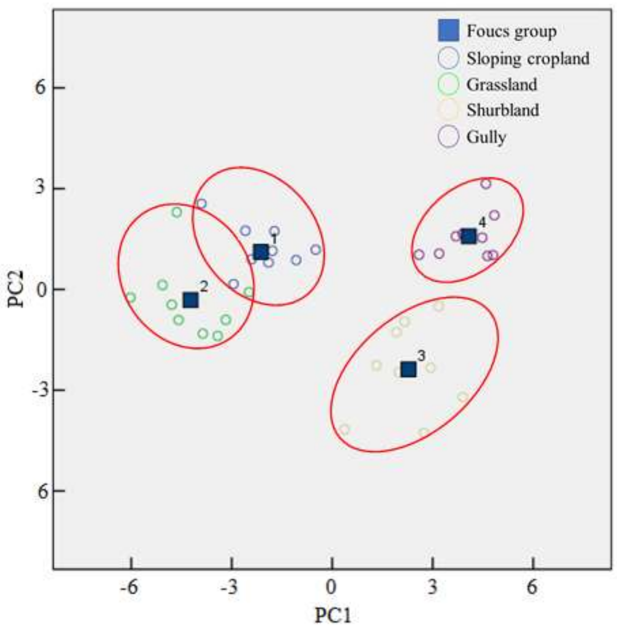
| Tracers | Uint | Sources | | | | Sediments | | | | Sediments samples inside[a] | Sediments mean inside[b] | H value | P value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Mean | Max | CV | Min | Mean | Max | CV | | | | |
| V | mg/kg | 32.42 | 59.28 | 76.14 | 0.17 | 34.76 | 52.23 | 75.04 | 0.15 | P | P | 13.304 | 0.004** |
| Cr | mg/kg | 22.68 | 71.47 | 120.04 | 0.39 | 24.29 | 64.24 | 117.64 | 0.38 | P | P | 28.117 | 0.000** |
| Mn | mg/kg | 394.67 | 612.43 | 994.25 | 0.29 | 427.74 | 597.44 | 856.13 | 0.21 | P | P | 2.992 | 0.393 |
| Co | mg/kg | 9.53 | 17.78 | 26.25 | 0.26 | 12.52 | 16.81 | 23.38 | 0.18 | P | P | 1.8991 | 0.594 |
| Ni | mg/kg | 18.51 | 33.51 | 48.86 | 0.23 | 20.57 | 29.94 | 44.56 | 0.25 | P | P | 25.083 | 0.000** |
| Cu | mg/kg | 15.86 | 36.65 | 56.75 | 0.35 | 14.51 | 23.54 | 50.44 | 0.35 | | | | |
| Zn | mg/kg | 48.56 | 92.83 | 139.01 | 0.24 | 60.04 | 84.63 | 114.85 | 0.22 | P | P | 10.067 | 0.018* |
| As | mg/kg | 9.21 | 14.74 | 22.26 | 0.27 | 10.86 | 14.50 | 21.86 | 0.17 | P | P | 7.5405 | 0.057 |
| Sb | mg/kg | 2.18 | 11.40 | 29.31 | 0.59 | 11.62 | 16.93 | 24.29 | 0.21 | P | P | 7.2763 | 0.064 |
| TOC | mg/kg | 1.24 | 1.96 | 3.18 | 0.22 | 1.84 | 2.38 | 3.27 | 0.13 | P | P | 20.709 | 0.000** |
| $^{137}$CS | bq/kg | 0.04 | 0.86 | 5.43 | 1.24 | 1.22 | 2.81 | 4.43 | 0.32 | P | | | |
| Clay | % | 0.04 | 0.38 | 1.10 | 0.51 | 0.05 | 0.27 | 0.70 | 0.53 | P | | | |
| Slit | % | 8.54 | 29.16 | 39.86 | 0.27 | 15.22 | 24.58 | 42.31 | 0.28 | P | | | |
| Sand | % | 59.84 | 70.46 | 90.36 | 0.11 | 57.05 | 75.15 | 84.63 | 0.09 | P | P | 27.11 | 0.000** |

CV refers to the coefficient of variation, **Extremely significant at a level of 0.01,*significant at a level of 0.05.
a. Mean sediment concentration within the range of the source category mean values.
b. All sediment sample concentrations were within the range of the source sample values

Tracer factor selection：

According to the K-W test and two limit condition, six geochemical tracer factors were obtained(V, Cr, Ni, Zn, TOC and Sand) .

# Results

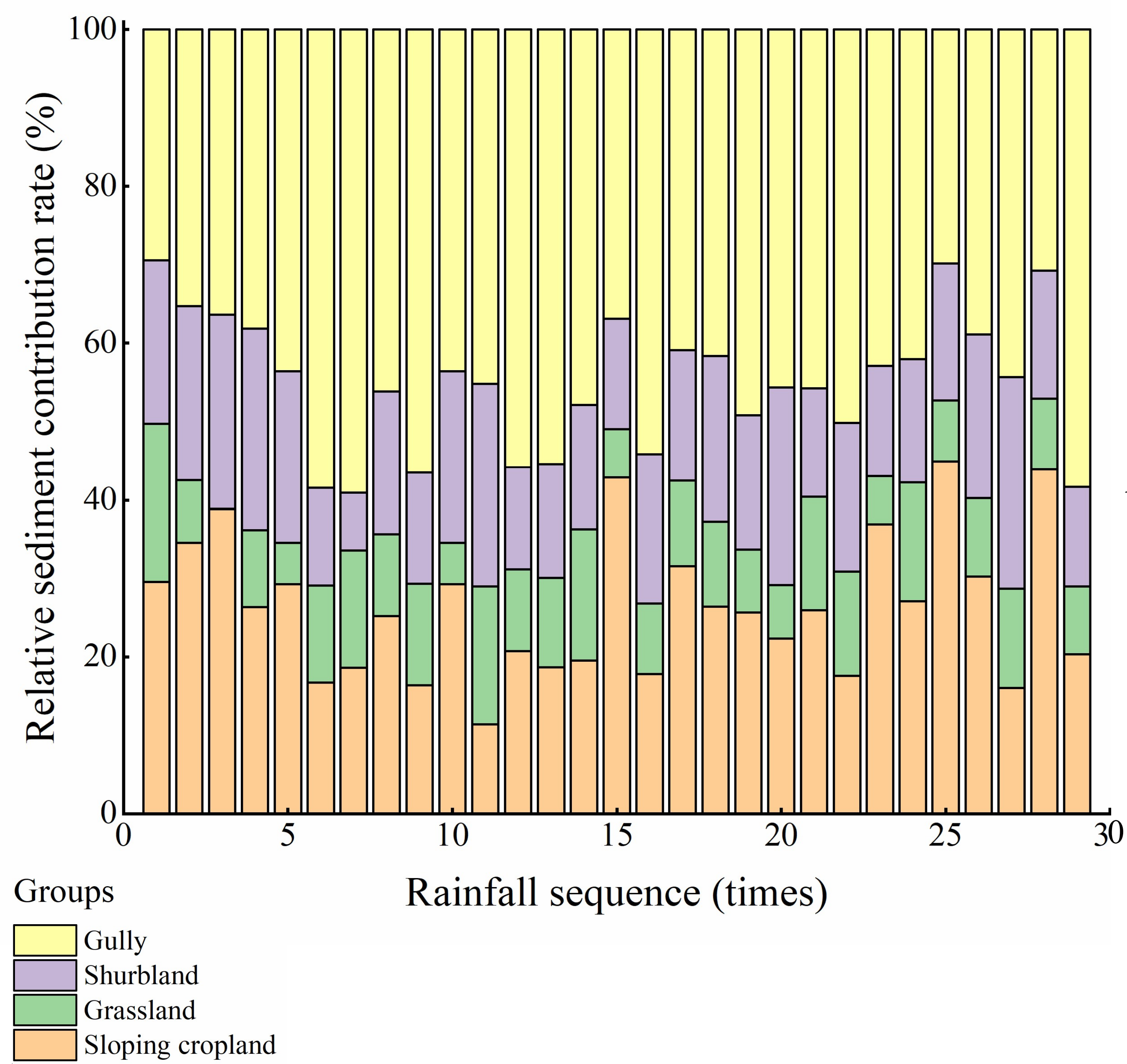



| | Source category | Predicted group information | | | | The total |
|---|---|---|---|---|---|---|
| | | Sloping cropland | Grassland | Shurbland | Gully | |
| The sample quantity | Sloping cropland | 8 | 1 | 0 | 0 | 9 |
| | Grassland | 0 | 9 | 0 | 0 | 9 |
| | Shurbland | 0 | 0 | 9 | 0 | 9 |
| | Gully | 0 | 0 | 0 | 9 | 9 |
| Distinguish rate % | Sloping cropland | 88.9 | 11.1 | 0.0 | 0.0 | 100.0 |
| | Grassland | 0.0 | 100.0 | 0.0 | 0.0 | 100.0 |
| | Shurbland | 0.0 | 0.0 | 100.0 | 0.0 | 100.0 |
| | Gully | 0.0 | 0.0 | 0.0 | 100.0 | 100.0 |

The best combination factor selected:

Based on the discriminant function analysis(DFA), the best combination factor (Cr, Ni, V, and TOC) selected in the study had a 97.2% recognition ability.

# Results

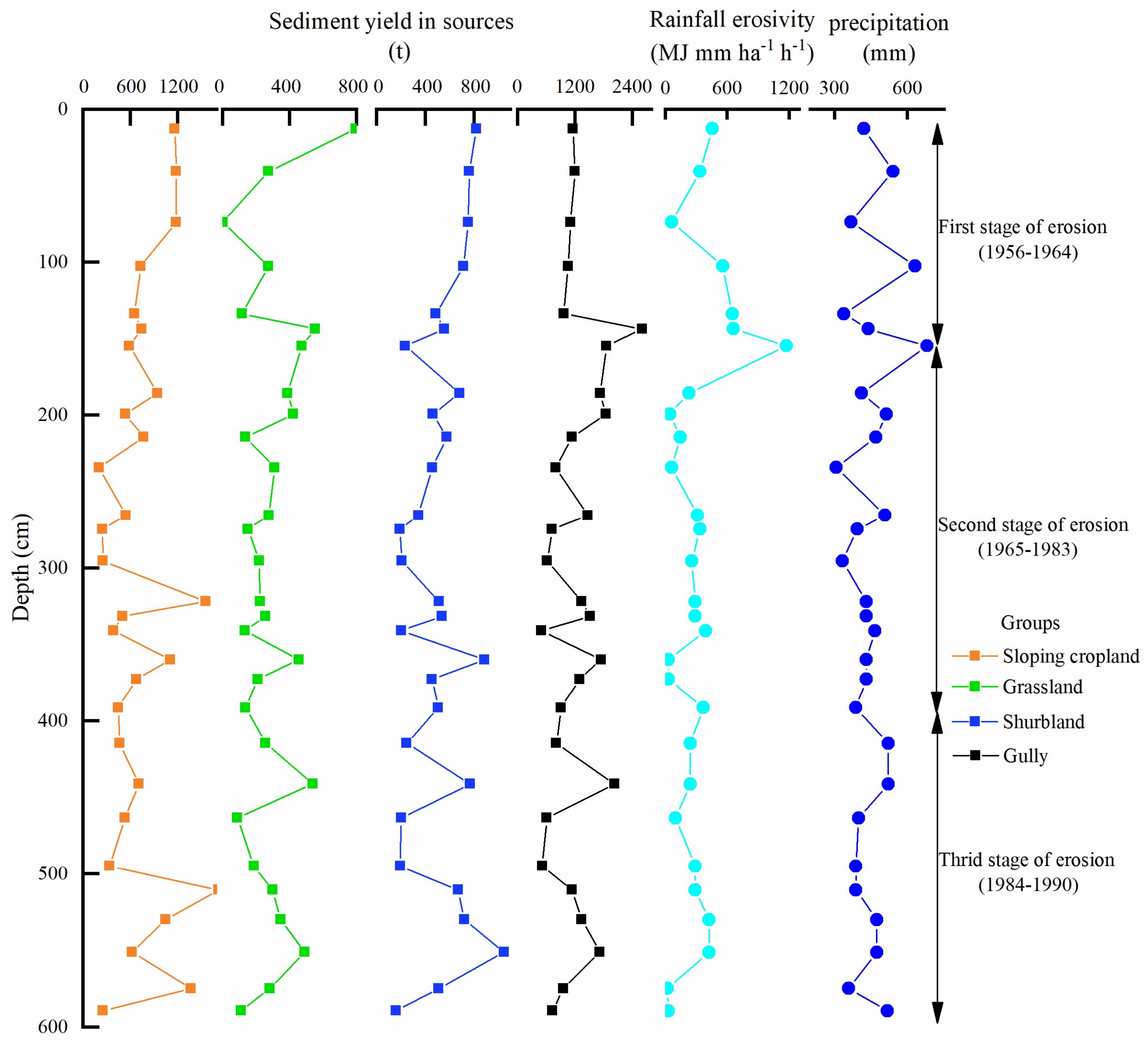



- A goodness of fit (GOF) was above 80%, and the results were credible.

Average source contribution:

- Gully (44.89%)
- Sloping cropland (26.38%)
- Shurbland (18.24%)
- Grassland (10.49%)

# Results



Sediment yield in sources
(t)
Rainfall erosivity
(MJ mm ha-1 h-1)
precipitation
(mm)
0 600 1200
0 400 800
0 400 800
0 1200 2400
0 600 1200
300 600
Depth (cm)
0
100
200
300
400
500
600
First stage of erosion
(1956-1964)
Second stage of erosion
(1965-1983)
Thrid stage of erosion
(1984-1990)
Groups
Sloping cropland
Grassland
Shurbland
Gully

# Discussion

## ☐ The sediment yield records reflect soil erosion from the slope

- The mean erosion modulus during the observation period (1956-1990) was 12710 $t \cdot km^{-2}$.
- The main erosion source on the Loess Plateau was the gully area.

## ☐ Impact of land use change on erosion in sediment source areas

- First stage: Great Leap Forward (1956-1965), vegetation was destroyed and arable land increased (14160 $t \cdot km^{-2}$).
- Second stage: Active soil and water conservation policies were implemented (1966-1983), extensive vegetation restoration (9590 $t \cdot km^{-2}$).
- Third stage: Rural land contract responsibility system (1984-1990), the area of cultivated land increased and some vegetation was destroyed (13110 $t \cdot km^{-2}$).

## ☐ Land planning and management

- Unreasonable human activities are the important cause of soil erosion intensification.
- Soil and water loss can be controlled more efficiently through rational allocation of soil and water conservation measures on slopes and the construction of check dam measures.

# Conclusion

- Based on $^{137}Cs$ activity, 29 layers of flood events were identified in the sediment core of a check dam in Nianyangou watershed, which can be divided into three erosion stages :1956-1965, 1966-1983 and 1984-1990.
- The best combination factor (Cr, Ni, V, and TOC) selected in the study had a 97.2% recognition ability. The contribution rates of sediment from gully, sloping cropland, grassland, and shrubland were 44.89%, 26.38%, 10.49%, and 18.24%, respectively.
- Policies on land use planning and management can seriously affect the intensity of soil erosion in an area. Therefore, reasonable allocation of slope, soil and water conservation measures, and the construction of check dams are the best ways to reduce soil erosion in small watersheds.

Thank you for your watch!