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# Landscape analysis of runoff and sedimentation based on land use/cover change in two typical watersheds on the Loess Plateau

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# Introduction

- **Water & soil loss, land use change, ecological functions of landscape patterns.**
- **Loess Plateau, semi-arid, water-limited, particularly sensitive to a deterioration in environmental quality**
- **Quantitative relationships between landscape metrics (LMs), and water and soil loss is crucial.**

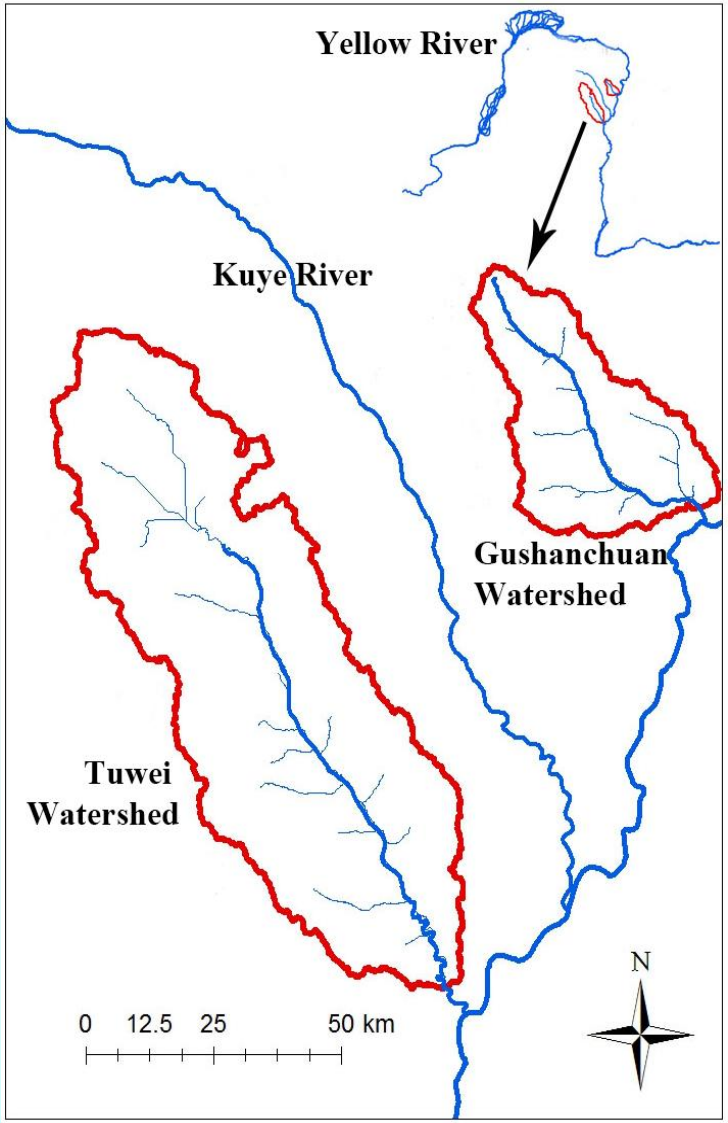
# Materials and Methods

**DEM** dataset : the Geospatial Data Cloud, the Computer Network Information Center, Chinese Academy of Sciences (http://www.gscloud.cn).

**Land use** dataset: provided by the Cold and Arid Regions Science Data Center at Lanzhou, China (http://westdc.westgis.ac.cn) analyzed by ArcGIS

**Annual runoff and sedimentation**: 1985–2010

Tuweihe (Tu) watershed & Gushanchuan (Gu) watershed



# Materials and Methods

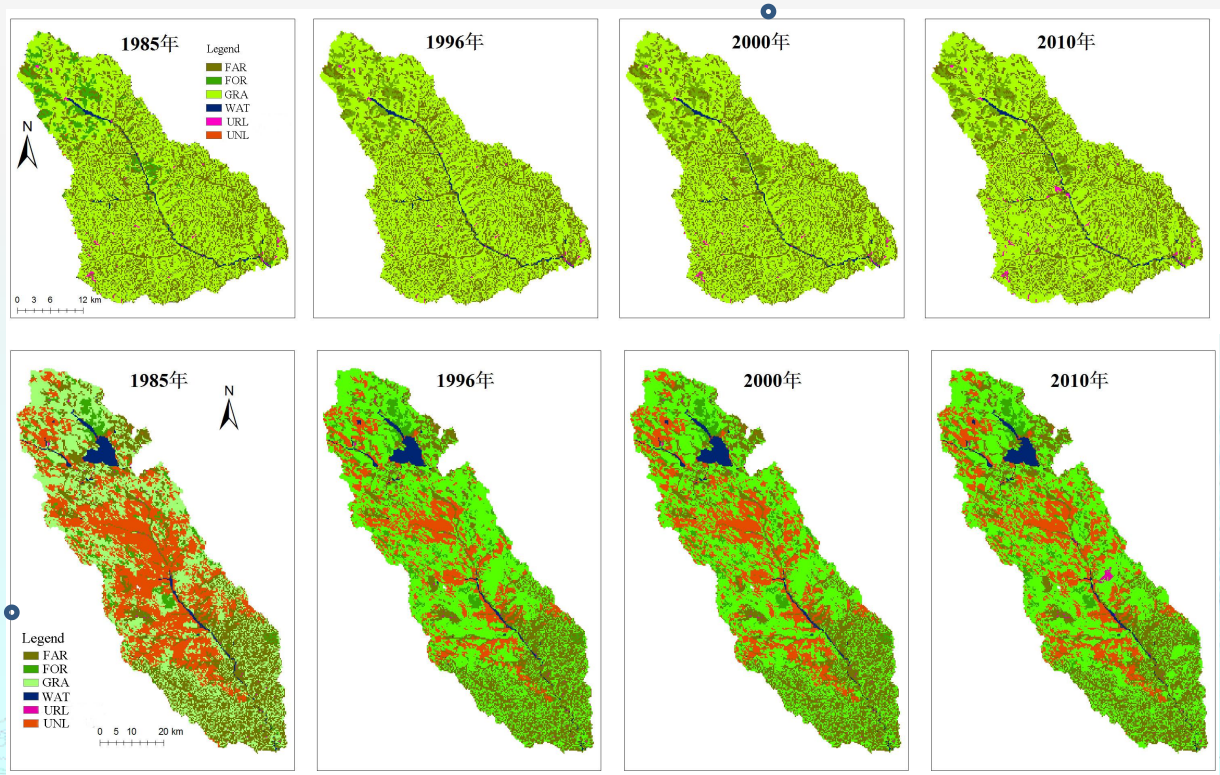
**Landscape metrics (LMs):** Fragstats 3.3

Patch level; Class level; landscape level

number of patches (NP), patch density (PD), the largest patch index (LPI), the landscape shape index (LSI), the perimeter area fractal dimension (PAFRAC), the contagion index (CONTAG) the patch cohesion index (COHESION), the landscape division index (DIVISION), Shannon's diversity index (SHDI), and Shannon's evenness index (SHEI).

**Gu watershed**

**Tu watershed**



# Results-land use changes

Land use characteristics in the study area ($km^2$)

| Land use | Tuweihe watershed | | | | Gushanchuan watershed | | | |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 1996 | 2000 | 2010 | 1985 | 1996 | 2000 | 2010 |
| FAR | 1129.26 | 1134.52 | 1116.35 | 1086.42 | 410.49 | 405.94 | 409.21 | 383.59 |
| FOR | 203.77 | 201.87 | 204.74 | 212.33 | 60.47 | 48.41 | 64.45 | 72.91 |
| GRA | 1681.02 | 2251.95 | 2124.38 | 2175.39 | 772.61 | 790.87 | 770.47 | 785.15 |
| WAT | 106.10 | 105.44 | 104.98 | 102.97 | 12.37 | 12.82 | 12.10 | 12.22 |
| URL | 8.70 | 8.62 | 9.03 | 18.65 | 6.12 | 4.51 | 6.32 | 8.53 |
| UNL | 1374.55 | 801.00 | 943.91 | 909.61 | 1.05 | 0.56 | 0.56 | 0.55 |

farmland (FAR), forest land (FOR), grassland (GRA), water (WAT), urban and rural land (URL), and unused land (UNL)

**Grassland (GRA)**: the greatest proportion of the land cover

**Unused land (UNL)**: had the highest transfer **ratio**, but **farmland (FAR) area** changed the most.

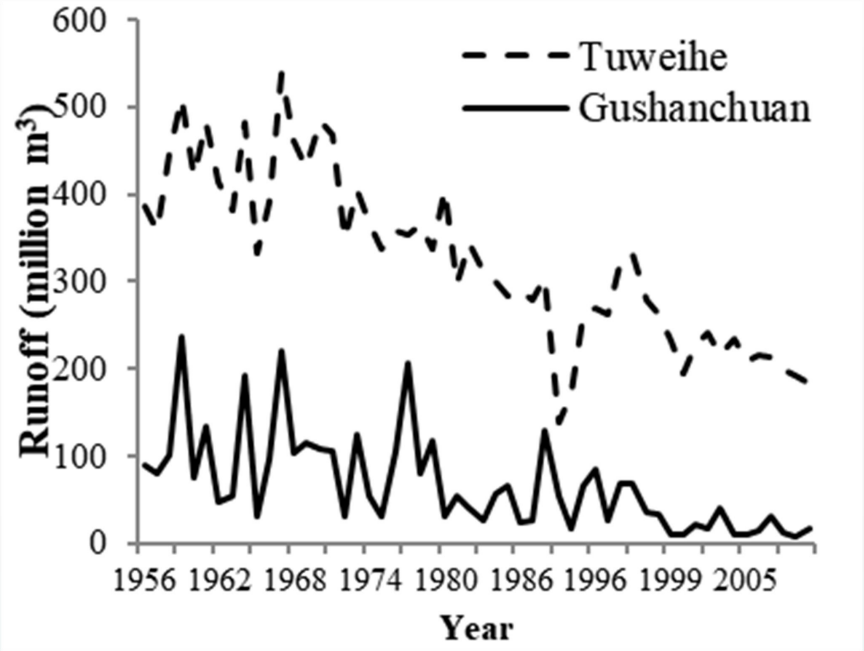
# Results-Landscape Metrics

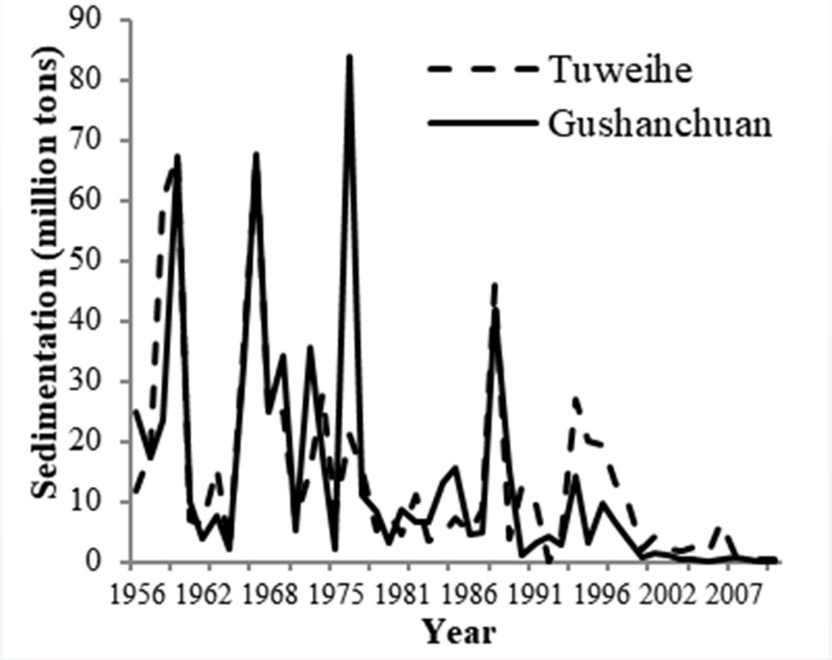
Land use characteristics in the study area ($km^2$)

| | Time | NP | PD | LPI | LSI | PAFRAC | CONTAG | COHESION | DIVISION | SHDI | SHEI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tu watershed | 1985 | 1393 | 0.31 | 20.30 | 36.48 | 1.60 | 36.47 | 97.79 | 0.91 | 1.32 | 0.734 |
| | 1996 | 1332 | 0.30 | 41.04 | 35.32 | 1.58 | 39.82 | 98.72 | 0.80 | 1.24 | 0.690 |
| | 2000 | 1343 | 0.30 | 37.39 | 36.16 | 1.58 | 38.46 | 98.60 | 0.83 | 1.27 | 0.706 |
| | 2010 | 1340 | 0.30 | 34.03 | 35.94 | 1.57 | 38.36 | 98.44 | 0.86 | 1.27 | 0.707 |
| Gu watershed | 1985 | 938 | 0.74 | 61.00 | 37.14 | 1.68 | 53.34 | 99.18 | 0.62 | 0.89 | 0.495 |
| | 1996 | 909 | 0.72 | 62.50 | 36.34 | 1.69 | 55.22 | 99.21 | 0.61 | 0.85 | 0.476 |
| | 2000 | 959 | 0.76 | 60.81 | 37.27 | 1.69 | 53.07 | 99.17 | 0.63 | 0.89 | 0.498 |
| | 2010 | 928 | 0.74 | 61.79 | 35.73 | 1.68 | 52.59 | 99.14 | 0.62 | 0.91 | 0.506 |

The landscape in the study area, Tu watershed especially, tended to become **regular, connected, and aggregated**. The landscape stability of the TU watershed was higher than that of the GU watershed.

# Results-variations of runoff and sedimenatation

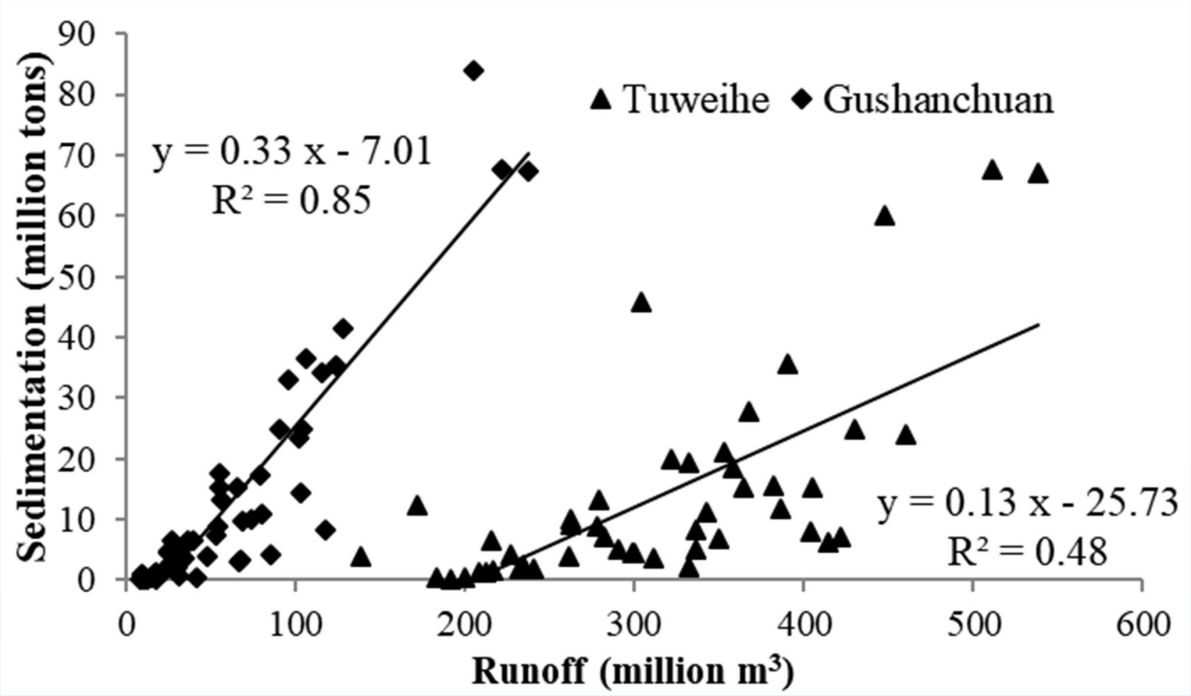



MK test: runoff and sedimentation tended to **decrease over time**

**Runoff** in the TU watershed ( with a larger area) was **higher** than that in the GU watershed, but annual **sedimentation** was **much the same**.

# Results-variations of runoff and sedimenatation




The sediment-carrying capacity of the runoff (i.e., the slope of the regression line) in the GU watershed was greater than that in the TU watershed.

# Results-Response relationships between runoff, sedimentation, and LMs

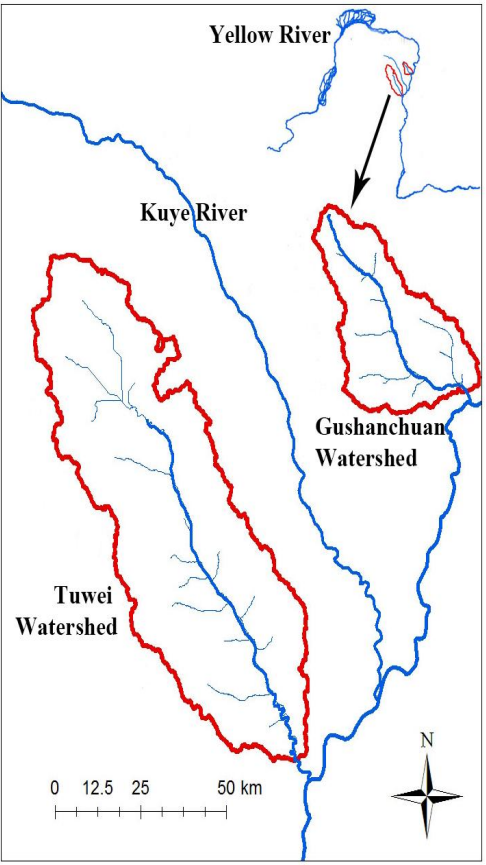
| | LMs | Regression equation | $R^2$ | Sig. |
|---|---|---|---|---|
| Runoff | PD | -4.457PD+5.010 | 0.916 | 0.003** |
| | SHAPE_AM | -0.1352SHAPE_AM+3.982 | 0.868 | 0.007** |
| | CONTAG | -0.113CONTAG+8.191 | 0.738 | 0.028* |
| | COHESION | -0.717COHESION+71.936 | 0.773 | 0.021* |
| | PRD | -334.76PRD+4.0689 | 0.840 | 0.01* |
| | SHDI | 3.312SHDI-3.361 | 0.930 | 0.002** |
| | SIDI | 9.788SIDI-5.135 | 0.915 | 0.003** |
| | SHEI | 12.280SHEI-4.937 | 0.934 | 0.002** |
| | SIEI | 9.808SIEI-5.588 | 0.916 | 0.003** |
| Sedimentation | CONTAG | -0.006CONTAG+0.474 | 0.693 | 0.04* |
| | COHESION | -0.043COHESION+4.294 | 0.760 | 0.024* |

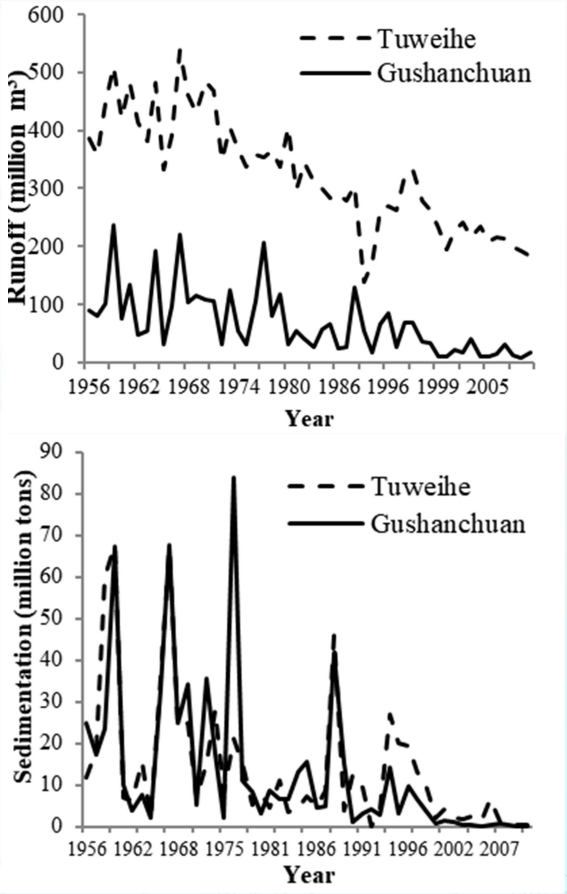
**More LMs** were significantly ($P < 0.05$) or highly significantly ($P < 0.01$) correlated with annual **runoff**.

**CONTAG & COHESION** had direct impacts ($P < 0.05$) on sedimentation.

# Discussion

- **Grain for Green Program** particularly affected Loess Plateau
- **Lower landscape stability** & **lager ratio of FAR** caused more sedimentatiom




# Discussion

**SHEI & COHESION:** the most significant factors affecting annual runoff and sedimentation

| Dependent | Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|
| | | | B | Std. Error | Beta | | | Tolerance | VIF |
| runoff | 1 | (Constant) | -4.937 | 0.876 | | -5.636 | 0.005 | | |
| | | SHEI | 12.280 | 1.630 | 0.967 | 7.534 | 0.002 | 1.000 | 1.000 |
| | 2 | (Constant) | 25.492 | 6.921 | | 3.683 | 0.035 | | |
| | | SHEI | 8.895 | 1.032 | 0.700 | 8.618 | 0.003 | 0.446 | 2.244 |
| | | COHESION | -0.292 | 0.066 | -0.358 | -4.403 | 0.022 | 0.446 | 2.244 |
| sedimentation | 1 | (Constant) | 4.294 | 1.184 | | 3.627 | 0.022 | | |
| | | COHESION | -0.043 | 0.012 | -0.871 | -3.554 | 0.024 | 1.000 | 1.000 |

# Conclusion

- Anuual runoff and sedimentation decreased with time because of vegetation restoration.
- Larger FAR area and lower landscape stability caused more sedimentation
- The LMs had more significant effects on runoff than that on sedimentation yield.
- Shannon's evenness index and the patch cohesion index were the key factors of influencing water and soil loss.


Thank you!