Spatiotemporal Evolution of Soil Erosion and Analysis of Influencing Factors in Ordos City: Postprint

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Abstract

Accurately assessing the spatiotemporal variation of soil erosion in Ordos City and investigating its influencing factors provides a reference for ecological environment management and soil and water conservation in mining areas of this region. This study employs the RUSLE model and the geographical detector method to investigate the status of soil water erosion in Ordos City from 2000 to 2019 and analyze its influencing factors. The results indicate that: (1) The average soil erosion amounts in Ordos City for the years 2000, 2005, 2010, 2015, and 2019 were 3865.49 t · km-2 · a-1, 2932.85 t · km-2 · a-1, 2890.21 t · km-2 · a-1, 3711.10 t · km-2 · a-1, and 4308.21 t · km-2 · a-1, respectively. During the 20-year study period, the average soil erosion amount first decreased and then increased, with the intensification of mining activities being the primary cause of aggravated soil erosion. (2) The soil erosion conditions within the 20 km buffer zone of coal mining areas are developing in a positive direction, indicating that ecological management measures in mining areas are effective and feasible. (3) Slope exhibits the strongest explanatory power for soil erosion in Ordos City and is identified as the dominant factor, while the synergistic effects among factors enhance the explanatory power for soil erosion. Soil erosion in Ordos City is dominated by slight and mild erosion; areas with slopes >35°, vegetation coverage of 0–0.3, and industrial and mining land are regions prone to soil erosion. Therefore, appropriately increasing vegetation coverage can effectively prevent and control soil and water loss.

Analysis of Temporal-Spatial Evolution and Influencing Factors of Soil Erosion in Ordos City

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Abstract

Accurately evaluating the spatiotemporal variation of soil erosion in Ordos City and investigating its influencing factors provides a reference for ecological environment management and soil and water conservation in mining areas. This study employs the Revised Universal Soil Loss Equation (RUSLE) model and geographic detector method to analyze hydraulic soil erosion conditions and their influencing factors in Ordos City from 2000 to 2019. The results indicate: (1) The average soil erosion amounts in 2000, 2005, 2010, 2015, and 2019 were 3865.49 $t \cdot km^{-2}$, 2932.85 $t \cdot km^{-2}$, 2890.21 $t \cdot km^{-2}$, 3711.10 $t \cdot km^{-2}$, and 4308.21 $t \cdot km^{-2}$, respectively. The average soil erosion amount initially decreased and then increased over the 20-year study period, with increased mining activity identified as the primary cause of aggravated soil erosion. (2) Soil erosion conditions within a 20 km buffer zone of mining areas showed improvement, demonstrating that ecological management measures in mining areas are effective and feasible. (3) Slope exhibited the strongest explanatory power for soil erosion in Ordos City and was identified as the dominant factor. The synergistic effects between factors enhanced their explanatory power for soil erosion. Soil erosion in Ordos City was dominated by slight and mild erosion, with areas having slopes >35°, vegetation coverage of 0-0.3, and industrial/mining land being particularly prone to soil erosion. Therefore, appropriately increasing vegetation coverage can effectively prevent soil and water loss.

Keywords: soil erosion; RUSLE model; geographic detector; coal mining area; impact factor; Ordos City

1 Introduction

Soil erosion destroys soil resources, affects soil fertility, exacerbates flood disasters, impacts the global carbon cycle, and poses significant threats to human survival and sustainable ecological development, making it a critical constraint on global resources and the environment. According to the Food and Agriculture

Organization of the United Nations, the world has lost one-third of its arable land due to intensified soil erosion from human activities. China’ s soil erosion situation is severe, with the latest “China Water and Soil Conservation Bulletin 2020” reporting that 269.27$×10^{4}$ km^2 of land experienced soil erosion, accounting for 28.05% of China’ s total land area. Western regions are particularly affected, with erosion areas exceeding 50% of their total area. Therefore, quantitative research on the spatial distribution and temporal evolution of soil erosion, along with analysis of its driving mechanisms and influencing factors, provides important reference value for developing prevention measures and policies, and is significant for regional sustainable development and ecological security.

Compared with traditional field observation methods for obtaining soil erosion data, the combination of remote sensing and geographic information systems to establish soil erosion models is more applicable and scientific. Due to convenient parameter acquisition and simple structure, the Revised Universal Soil Loss Equation (RUSLE) is widely applied in soil erosion research. Recent studies based on this model have focused on two main aspects. First, research on spatiotemporal variation characteristics and prediction of soil erosion. For example, Zhang et al. used the RUSLE model to analyze soil erosion intensity under different land use types, elevations, and slope conditions in the Sunshui River Basin of Liangshan Prefecture, quantitatively evaluating the spatial characteristics of soil erosion in the study area. Melese et al. used Landsat imagery and field measurement data to comprehensively assess the impact of land use change on soil erosion in the Tagaw Watershed over the past 30 years, finding that bare land and farmland were more prone to soil erosion than other land use types, with significant impacts from land use change. Islam et al. evaluated potential soil erosion in the Langat River Basin using the RUSLE model. Alitane et al. used the RUSLE model and the Soil and Water Assessment Tool (SWAT) to quantify and predict soil erosion rates in the R’ Dom Watershed in Morocco for baseline (2004-2014) and future (2041-2070) periods.

Second, combining soil erosion results with driver analysis and risk assessment can clarify management directions. For instance, Jia et al. used the geographic detector method to explore driving factors of soil erosion in the Weihe River Basin, identifying vegetation coverage, afforestation area, and precipitation as the main factors affecting the spatial distribution of soil erosion. Tian et al. used the RUSLE model with overlay analysis and regional statistics to investigate the relationship between elevation, slope, landform, and soil erosion in the Qinjiang River Basin of Guangxi’ s Beibu Gulf region, providing targeted soil and water conservation recommendations for areas requiring priority prevention. Mhaske et al. studied soil erosion in Jharkhand’s Saland forest in India using the RUSLE model and analytic hierarchy process, finding that hilltop mining areas occupying less than 5% of the area had extremely high soil erosion risk, and proposed relevant management recommendations.

As an important energy city in Inner Mongolia located in the transition zone between central and western China and at the agro-pastoral ecotone, Ordos City serves as an ecological barrier. Quantitative analysis of soil erosion distribution and evolution is significant for scientifically conducting ecological restoration projects. Therefore, this study combines the RUSLE model with geographic detectors to investigate the spatiotemporal variation of hydraulic soil erosion in Ordos City from 2000 to 2019, analyze its influencing factors, and provide a scientific basis for ecological environment management and soil and water conservation in the region.

1.1 Study Area Overview This study selected Ordos City in arid and semi-arid regions as the research area. The geographical location and overview are shown in [Figure 1: see original paper]. Ordos City has a terrain that is higher in the east and lower in the west, with undulating topography and complex, diverse landform types including loess hilly gullies, deserts, sandy land, and plains. The city is surrounded by the Yellow River on its east, north, and west sides, with an average elevation of 1000-1500 m. The climate is temperate semi-arid continental, with an average annual temperature of approximately 6.2°C and average annual precipitation of about 400 mm. The study area features typical desert steppe vegetation, with main soil types being chestnut soil, brown calcic soil, sierozem, and gray desert soil. The soil texture is loose, easily weathered, and susceptible to rainwash erosion. Vegetation consists mainly of xerophytic plants with low coverage. Ordos City has more than 50 types of mineral resources, with abundant reserves of coal, natural gas, and rare earth elements, making it an important coal chemical industry base and a key national ecological protection and management area.

1.2 Data Sources and Processing The study utilized MODIS and Landsat data from the Geospatial Data Cloud (http://www.gscloud.cn/), precipitation data from the China Meteorological Data Network (http://data.cma.cn), ASTER GDEM data from NASA's official website (https://ladsweb.nascom.nasa.gov), landform type data from the National Tibetan Plateau Scientific Data Center (http://www.tpdc.ac.cn), soil data from the Resource and Environmental Science Data Center of the Chinese Academy of Sciences (http://www.resdc.cn), and vector data from Tianditu. Mining area boundaries were obtained through field investigation, and mining point data were derived from land use classification data combined with field surveys. In Ordos City, 15 underground mining points and 5 open-pit mining surfaces were selected for soil erosion research in mining areas, mainly including the Shendong mining area and Qipanjie mining area. All data were unified to the CSCS_{2000} coordinate system, with raster data resampled to 30 m$×$30 m resolution. Data sources and parameters are detailed in .

2 Research Methods

2.1 RUSLE Model The RUSLE model was used to estimate soil erosion in Ordos City, with each factor determined according to the characteristics of the study area and data availability. The RUSLE model formula is as follows:

$$A = R \times K \times L \times S \times C \times P$$

where: A is annual soil erosion ($\mathrm{t} \cdot \mathrm{km}^{-2}$), with conversion units of 10 $\mathrm{t} \cdot \mathrm{hm}^{-2}$; R is the rainfall erosivity factor; K is the soil erodibility factor; L is the slope length factor; S is the slope steepness factor; C is the vegetation cover and management factor; and P is the soil and water conservation practice factor.

Rainfall erosivity reflects soil loss caused by precipitation scouring the surface. The method proposed by Zhang et al., which uses daily precipitation data with high accuracy, was adopted to calculate the rainfall erosivity factor R:

$$M_i = \sum_{j=1}^{N} D_j^{\beta}$$

$$R = \sum_{i=1}^{24} M_i$$

where: M_i is the erosivity value for the i-th half-month period; N is the number of days in that half-month period; D_j is the daily precipitation on day j of the half-month period (requiring daily precipitation \$ \$12 mm); and α and β are parameters.

Soil erodibility measures the natural resistance of soil to external forces. The EPIC (Erosion Productivity Impact Calculator) model was used to calculate the K value:

$$K = \{0.2{+}0.3\exp[-0.0256 S_a (1{-}S_i/100)]\} \times \left(\frac{S_i}{C_i + S_i}\right)^{0.3} \times \left[1 - \frac{0.25C}{C + \exp(3.72 - 0.95C)}\right] \times \left[1 - \frac{0.7}{S_n + \exp(-5.}\right.$$

where: S_a is sand content (%); S_i is silt content (%); C_i is clay content (%); C is organic carbon content (%); and $S_n = 1 - S_a/100$.

The formula was revised for applicability in China:

$$K = 0.1317 \times \{0.2{+}0.3\exp[-0.0256 S_a (1{-}S_i/100)]\} \times \left(\frac{S_i}{C_i + S_i}\right)^{0.3} \times \left[1 - \frac{0.25C}{C + \exp(3.72 - 0.95C)}\right] \times \left[1 - \frac{}{S_n +}\right.$$

Slope length and steepness factors reflect the influence of terrain undulation and geomorphological characteristics on soil erosion. The universal method established by Renard et al. was used to calculate the slope length factor L and slope steepness factor S:

$$L = \left(\frac{\lambda}{22.13}\right)^m$$

$$S = \begin{cases} 10.8\sin\theta + 0.03, & \theta < 5.1428^\circ \\ 16.8\sin\theta - 0.50, & 5.1428^\circ \le \theta < 14.0362^\circ \\ 21.91\sin\theta - 0.96, & \theta \ge 14.0362^\circ \end{cases}$$

where: λ is slope length; m is the slope length exponent; and θ is slope steepness.

Increasing vegetation coverage and improving management practices can inhibit soil erosion to some extent. The method proposed by Cai et al. was used to estimate the C value:

$$f = \frac{\mathrm{NDVI} - \mathrm{NDVI}_{\mathrm{soil}}}{\mathrm{NDVI}_{\mathrm{veg}} - \mathrm{NDVI}_{\mathrm{soil}}}$$

$$C = \begin{cases} 1, & f \le 0.1\% \\ 0.6508 - 0.3436\lg f, & 0.1\% \le f \le 78.3\% \\ 0, & f \ge 78.3\% \end{cases}$$

where: f is vegetation coverage; NDVI is the normalized difference vegetation index; $\mathrm{NDVI}_{\mathrm{soil}}$ and $\mathrm{NDVI}_{\mathrm{veg}}$ are defined as NDVI values for bare soil and fully vegetated conditions, respectively.

The soil and water conservation practice factor P inhibits soil erosion through specific tillage methods or by altering microtopography, retaining surface runoff, increasing infiltration, and improving agricultural production conditions to maintain soil and water resources and fertility. In Ordos City, cultivated land consists mainly of dry land and some irrigated land, while grassland comprises natural pasture and some artificial pasture. Based on Ordos City’ s land use status, slope information, and previous research results, the revised P factor values were determined (,).

2.2 Geographic Detector The geographic detector model proposed by Wang et al. was used to analyze soil erosion influencing factors in Ordos City. Geographic detector is a tool for detecting spatial heterogeneity, employing factor detection, interaction detection, and risk detection modules to identify influencing factors of soil erosion and interpret their interactions and significant differences, providing reference for ecological management in arid and semi-arid regions.

The factor detector assesses the explanatory power of factor X on attribute Y, expressed as q value ($0 \le q \le 1$). A larger q value indicates a more significant effect of the independent variable on the dependent variable:

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{\mathrm{SSW}}{\mathrm{SST}}$$

where: SSW is the sum of within-layer variances; SST is the total variance; $h = 1, \ldots, L$ represents strata of attribute Y or factor X; N_h and N are the number of units in layer h and the entire region, respectively; and σ_h^2 and σ^2 are variances of Y values in layer h and the entire region, respectively.

The interaction detector, a key advantage of geographic detectors, identifies interactive effects of dual factors on Y (). The risk detector identifies whether mean attribute values differ significantly among sub-regions by comparing mean soil erosion amounts under different categorical partitions of each influencing factor to identify high-risk areas.

Soil erosion amount was selected as the dependent variable, while vegetation coverage, annual precipitation, slope, land use type, and distance from mining areas were chosen as independent variables. Continuous data were discretized according to geographic detector requirements: land use data were classified by category; vegetation coverage data were divided into 0-0.3, 0.3-0.4, 0.4-0.5, 0.5-0.6, 0.6-0.7, 0.7-0.8, 0.8-0.9, and 0.9-1 classes; slope data were divided into 0-5°, 5°-10°, 10°-15°, 15°-20°, 20°-25°, 25°-30°, 30°-35°, and 35°-90° classes; and distance from mining areas was divided into 5 classes using the natural breaks method. Ordos City was divided into 2 km$\times$2 km grid cells, with each cell' s center point set as a sample point and assigned attribute values for geographic detector analysis.

3 Results

3.1 Spatiotemporal Distribution Characteristics of Soil Erosion

3.1.1 Spatial Distribution of Soil Erosion Based on the "Standards for Classification and Gradation of Soil Erosion (SL190-2007)" and using ArcGIS 10.5 spatial analysis functions, soil erosion in the study area from 2000 to 2019 was calculated using the RUSLE model. Results were classified into 6 grades (slight, mild, moderate, strong, very strong, and severe erosion) to produce soil erosion intensity maps for Ordos City ([Figure 2: see original paper]). The spatial distribution pattern is similar to Zhou et al.' s research, and the temporal variation pattern is consistent with Bai et al.' s study, confirming the reliability of the results and the good applicability of the RUSLE model in the study area.

From the perspective of average soil erosion amount, soil erosion conditions in Ordos City changed significantly from 2000 to 2019. During the first 15 years, average soil erosion showed a decreasing trend, dropping from 3865.49 $\mathrm{t \cdot km^{-2}}$ in 2000 to 2890.21 $\mathrm{t \cdot km^{-2}}$ in 2015. With rapid economic development and increased mining activities, average soil erosion rose to 3711.10 $\mathrm{t \cdot km^{-2}}$ in 2019, reaching the maximum value of 4308.21 $\mathrm{t \cdot km^{-2}}$. Overall, the average soil erosion amount showed a trend of first decreasing and then increasing during the 20-year period. The area proportions of different erosion grades are shown in .

3.1.2 Temporal Variation of Soil Erosion To further analyze the spatiotemporal variation characteristics of soil erosion in Ordos City over the past 20 years, the 5-period data were divided into four time intervals: 2000-2005, 2005-2010, 2010-2015, and 2015-2019. Using ArcGIS 10.5 spatial analysis functions, soil erosion intensity changes in Ordos City were obtained ([Figure 3: see original paper]). During 2000-2005, the area of slight and mild erosion increased, while very strong and severe erosion areas decreased annually, indicating good soil and water conservation effects. During 2005-2010, the opposite occurred, with soil erosion conditions worsening, likely due to intensified coal mining. During 2010-2015, 57.22% of the area showed no change in soil erosion intensity grade, 34.77% showed decreased intensity, mainly distributed in Jungar Banner, southwestern Otog Banner, and western Hanggin Banner, indicating improved soil erosion conditions in most areas due to effective conservation measures. During 2015-2019, 49.00% of the area showed no grade change and 43.87% showed decreased intensity, while areas with increased intensity rose to 7.13%, mainly distributed in western and central Ordos City and sporadically in Jungar Banner, Dongsheng District, and Kangbashi District, generally presenting a recumbent "T" shape distribution. These areas mostly have steep terrain where soil is easily eroded, suggesting the need for enhanced soil and water conservation facilities.

3.2 Analysis of Influencing Factors

3.2.1 Land Use Type Ordos City' s land use types consist mainly of cultivated land, grassland, urban land, industrial/mining land, other land, and water bodies ([Figure 4: see original paper]). Grassland and other land account for the largest proportion, together comprising over 70% of the total area, while other land use types occupy smaller proportions. Significant changes occurred in land use types from 2000 to 2019 (except for minimal changes in water bodies and grassland). The areas of cultivated land, industrial/mining land, and urban land generally increased annually, while other land showed a decreasing trend.

Based on soil erosion and land use data from 2000 to 2019, the average soil erosion amount for each land use type was calculated. The results show significant differences in soil erosion conditions among different land use types, with industrial/mining land having the highest average soil erosion amount and urban land the lowest (). Industrial/mining land and other land are the main land use types causing erosion in Ordos City, while urban land and cultivated land show lighter erosion conditions, indicating that increased human intervention can significantly impact regional soil erosion. The substantial reduction in regional erosion from 2000 to 2015 was mainly due to increased grassland and cultivated land and significantly decreased other land. After more than 15 years of comprehensive management, changes in regional land use patterns have effectively reduced soil erosion.

3.2.2 Terrain Slope, defined as the angle between the ground surface and the horizontal plane, reflects the degree of surface inclination and is closely related to soil erosion intensity. Following Zhang et al.' s research, slope was divided into eight categories: 0-5°, 5°-8°, 8°-15°, 15°-25°, 25°-35°, and 35°-90°. The average soil erosion amount for each slope zone in Ordos City was calculated ([Figure 5: see original paper], [Figure 6: see original paper]). The results show a clear positive correlation between average soil erosion amount and slope gradient. Soil erosion conditions were best in 2015, with the lowest average soil erosion amounts across all slope zones. Areas with slopes below 8° account for 60% of Ordos City' s total area. The soil erosion conditions in the 8°-15° and 5°-8° slope zones are consistent with the overall city trend, showing a pattern of first decreasing and then increasing. Although steep slope areas occupy a small proportion, their soil erosion conditions require attention.

3.2.3 Landform Type Landform reflects surface morphology and significantly influences human economic construction. Analyzing soil erosion under different landform types helps understand erosion differences and provides guidance for regional management. Ordos City has complex and diverse landform types, mainly accumulation and denudation landforms ([Figure 7: see original paper]). Medium-relief mountains have the highest average soil erosion amount, followed by denudation platforms, which have large terrain undulations and easily eroded soil. Loess hills and mound areas have moderate average soil erosion amounts. In 2019, the average soil erosion amount in loess mound areas increased abnormally, likely due to lagged effects of the rainy season and short-term heavy rain 冲刷. Alluvial and diluvial plains have lower average soil erosion amounts. Most diluvial-alluvial plains are located in valleys near Jungar Banner, where soil erosion is more severe compared to plains along the Yellow River, possibly because mining areas are often located in such regions. Aeolian landforms cover the largest area, including the Kubuqi and Mu Us sandy lands, where soil erosion is relatively light, indicating the significant effectiveness of various ecological initiatives such as returning farmland to forest and afforestation.

3.2.4 Coal Mining Areas Integrating open-pit mining surfaces and underground mining point data, 20 km buffer zones were generated to analyze average soil erosion amounts within each zone. Overall, soil erosion conditions in Ordos City' s mining areas showed improvement trends. From 2000 to 2015, average soil erosion amounts decreased annually from 7029.68 $t \cdot km^{-2}$ to the minimum value of 3611.05 $t \cdot km^{-2}$. In 2019, soil erosion conditions worsened somewhat, with average soil erosion rising to 4931.30 $t \cdot km^{-2}$. The improvement in soil erosion conditions in mining areas since 2000 indicates that mine reclamation and ecological restoration have played significant roles in environmental recovery and management. Most mines in Ordos City are underground operations, which cause less surface environmental damage than open-pit mining, particularly reducing soil disturbance. Additionally, due to Ordos City' s emphasis on ecological restoration and management in mining areas, vegetation recovery around mining areas has been remarkable, which is one reason why distance from mining areas has relatively low explanatory power for soil erosion.

3.3 Analysis of Soil Erosion Influencing Factors

The geographic detector analysis shows significant differences in explanatory power among the selected influencing factors (). For Ordos City overall, the ranking of factors by explanatory power from strongest to weakest is: slope > land use type > vegetation coverage > annual precipitation > distance from mining areas. Slope has the strongest explanatory power with a q value of 0.387, indicating it is the dominant factor determining soil erosion conditions. Vegetation coverage ranks second with an explanatory power of 0.192, while distance from mining areas has the smallest q value, indicating the lowest impact on soil erosion.

The interaction detector reveals that the q values of dual-factor interactions are significantly higher than those of single factors, with the interaction between slope and vegetation coverage showing the highest explanatory power of 0.523 (). This indicates that terrain and soil erosion spatial distribution are strongly associated, and areas with large slope differences also show significant differences in soil erosion conditions. The analysis shows that natural environmental factors (slope, vegetation coverage, annual precipitation, land use type) have much greater explanatory power than the anthropogenic factor (distance from mining areas), suggesting that natural environmental factors are the main reasons affecting the spatial distribution of soil erosion in Ordos City.

The risk detector identifies high-risk areas for soil erosion by calculating average erosion amounts for each factor category (). Results show that areas with slopes >35° are highly prone to soil and water loss. Among land use types, industrial/mining land has relatively high average soil erosion. Areas with annual precipitation of 141.02-174.62 mm have higher potential for soil erosion. Regions with vegetation coverage of 0-0.3 have poor soil and water conservation capacity. Areas within 0-13,528 m of mining areas show higher soil erosion risk. Based on these findings, ecological restoration and management in Ordos City should focus on steep slope areas, low vegetation coverage regions, and industrial/mining land.

4 Discussion

This study analyzed the spatial distribution and influencing factors of soil erosion in Ordos City based on a long time series. Comparative analysis confirms the feasibility of using the RUSLE model for soil erosion estimation in the study area. Based on geographic detector analysis and soil erosion heterogeneity, the following recommendations are proposed: Ordos City should be divided into four management zones—western mountainous areas, eastern loess areas, central-southern sandy areas, and mining area soil-sensitive zones. Western mountainous areas have large terrain undulations and many steep slopes, requiring priority implementation of steep slope management, vegetation restoration, and upgrading of silt dams for water retention. Eastern loess areas should appropriately implement returning farmland to forest and closing hillsides for afforestation. Central-southern sandy areas should enhance public environmental awareness, promoting tree and grass planting as practical activities in schools and communities. For mining area soil-sensitive zones, vegetation coverage in surrounding areas should be increased, abandoned mines should undergo ecological restoration, and government supervision and preventive functions should be strengthened to legally manage soil erosion conditions.

However, this study has several limitations. First, the assignment of soil and water conservation factors was based on Landsat images after supervised classification and visual interpretation. Due to limited images during the plant growing season, cloud cover issues inevitably affected soil erosion accuracy. Future research should consider using higher temporal and spatial resolution images combined with field survey data for land use classification. Second, many factors influence soil erosion in Ordos City, but limited data availability restricted the selection of anthropogenic impact factors for geographic detector input. Future studies should more comprehensively analyze various factors affecting soil erosion to obtain more accurate factor assessments, providing more scientific recommendations for soil and water conservation ecological management and improving human-land relationships for regional sustainable development.

5 Conclusions

Through estimation and factor analysis of soil erosion in Ordos City from 2000 to 2019, the following conclusions are drawn:

1) Soil erosion in Ordos City is dominated by slight and mild erosion, with more severe erosion concentrated in the northwestern parts of Jungar Banner and Otog Banner. The average soil erosion amount from 2000 to 2019 first decreased and then increased, with good soil and water conservation effects during 2000-2015. Increased mining area due to economic development in 2019 aggravated soil erosion conditions.

2) Regarding land use types, industrial/mining land and other land are the main erosion-causing types. In terms of terrain, average soil erosion amount shows a clear positive correlation with slope gradient, with steep slope erosion requiring special attention in regional soil and water conservation work. Landform types with large terrain undulations have higher average soil erosion amounts, while management of aeolian landforms has achieved remarkable success. Through data integration and buffer analysis of mining areas, the average soil erosion amount within 20 km buffer zones was calculated, showing that soil erosion conditions in mining areas

have improved since 2000, indicating that mine reclamation and ecological restoration have played significant roles.

3) Geographic detector analysis of soil erosion influencing factors shows that slope has the greatest explanatory power, confirming it as the dominant factor in Ordos City. The interaction between slope and vegetation coverage has the strongest explanatory power, indicating that vegetation planting should be intensified in areas with large terrain undulations. Areas with slopes >35°, vegetation coverage of 0-0.3, and industrial/mining land are prone to soil erosion, requiring special attention to soil and water conservation in these high-risk areas.

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Note: Figure translations are in progress. See original paper for figures.