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Response Characteristics of Soil Erosion to Spatial Conflict in the Production-Living-Ecological Space and Their DrivingMechanism: A Case Study of Dongting Lake Basin in China

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Abstract: Land use conflicts induced by human activities cause accelerated soil erosion. The response of soil erosion to spatial conflict in production-living-ecological space (PLES) is not clearly understood. In this research, models such as PLES spatial conflict, revised universal soil loss equation, bivariate spatial autocorrelation, and an optimal parameter-based geographical detector were used to explore the characteristics and drivers of soil erosion in response to spatial conflict in the PLES of the Dongting Lake watershed. Results show that spatial changes of the PLES first increased and then decreased. Approximately 45% of the area was consistently in moderate or higher conflict levels throughout the study period. The average soil erosion rate showed a decreasing trend for each year except in the period 2000–2005, when moderate erosion increased. The spatial correlation between spatial conflict and soil erosion was found to be in the form of an inverted "U" for the high-high and low-high agglomeration patterns, and a decreasing trend for the high-low ones. Approximately 27% of the area must be traded off between the spatial conflict of the PLES and soil erosion. The influence of GDP and population density was significant. DEM interacted strongly with GDP, NDVI, precipitation, population density, and "return of farmland to forest" policy. Different patterns were formed among the factors through actions such as amplification, mitigation, catalysis, and dependence effects. We propose policy recommendations based on the differences in the driving mechanisms of the respective models.

Keywords: production-living-ecological space; spatial conflict; soil erosion; driving mechanism; Dongting Lake Basin

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1. Introduction

Land is a complex system wherein natural and human social elements interact in space. Land can be classified into production, living, and ecological spaces based on the function of land use [1–3]. The watershed is an essential space for both human socioeconomic functions and ecological functions. With the rapid progress of industrialization, urbanization and agricultural expansion, natural wetlands, biological habitats and other ecological spaces have been encroached upon and destroyed, ecological flows have been severely squeezed, and ecosystem integrity has been reduced [4,5]. Conflicts between urban, agricultural, and ecological spaces have intensified, and conflicts among the elements of the production-living-ecological space (PLES) have escalated leading to the degradation of watershed ecosystems [6]. A causal chain links the elements of the PLES. Spatial conflicts among the elements of the PLES affect biodiversity, climate change, other material cycles and ecological processes, leading to changes in the structure and function of the ecosystem [7,8]. Soil erosion in watersheds is a serious worldwide environmental problem. Extensive research has shown that land use changes caused by human activities are the primary cause of accelerated soil erosion [9,10]. Therefore, an understanding of the characteristics and

mechanisms of the spatiotemporal responses of soil erosion to the spatial conflicts of PLES can provide a scientific basis for optimizing land use and enhancing the ecological and environmental quality of a watershed.

The PLES is divided based on spatial planning and control orientation of the land, and the essence of its formation is the spatial function concentration of the territory [11]. The production space corresponds to the production of industrial and agricultural products and services. The living space is related to human activities including residential, consumption, leisure and recreation, etc. within urban and rural settlements. The ecological space is connected to the natural biosphere wherein the provision of ecological products and services are the dominant functions, and it plays an important role in regulating, maintaining and securing regional ecological security [12]. Such a classification is consistent with the nature and purpose of the three-system model consisting of social, economic, and environmental systems proposed by the United Nations Environment Programme and by various American nongovernmental organizations in 1997 [13,14]. The Chinese government considers the optimization of the PLES as a core element of its ecological civilization and sustainable development strategy, which aims for "promoting intensive and efficient production space, livable and moderate living space, and clear and beautiful ecological space." [12,15]. Previous studies have focused on the connotation and formation [12] and driving mechanisms of PLES [16,17], evaluated its ecological and environmental effects [18,19] and analyzed the coupling, coordination, and conflict that it caused [20–22]. Diagnosis of spatial conflicts is vital for identifying land use intensity and evaluating associated problems. The measurement of spatial conflict relating to a PLES is predominantly based on land conflict. The essence of the land use conflict problem is incompatibility and imbalance in the allocation of quantity and structure of land resources, and regional economic, social, and ecological environment and spatial development under certain spatial and temporal conditions, such as the conflict between urban expansion and farmland protection, the conflict between protected land and productive land (e.g., farmland and construction land), and the causality between overuse of land and land degradation [23]. Landscape spatial conflict is a spatial microcosm and comprehensive reflection of all conflicts, reflecting the incongruity of spatial structure of land use caused by the combined effect of natural changes and human activity disturbances. It can be used as a sensitive indicator of human-environment interaction [24,25].

First, identification of spatial conflicts in a PLES by evaluating the suitability of different land types is important. Jing et al. [26] identified potential land use conflicts by constructing a multi-objective suitability evaluation index system for production, living, and ecological land uses. Fang et al. [27] discerned spatial conflicts in the PLES of southwestern China's mountainous areas by constructing a multi-objective suitability evaluation model considering productivity, sustainability, and liability, and proposed governance recommendations for different functional units. Multiple suitability requirements of land use, scarcity of land resources, and diversity of human needs are fundamental causes of land use conflicts [28]. However, studies on suitability-based conflicts highlight the land itself under the action of external forces, and therefore, cannot directly reflect human-land interactions [24]. Second, the use of a comprehensive index model to calculate the spatial conflict index based on the complexity, vulnerability, and dynamics of the land system is important. For instance, Liao et al. [29] constructed a spatial conflict index by applying the method of landscape ecological index to analyze the spatial conflict of PLES in the Pingtan Island. Wang et al. [30] conducted a multivariate linear logistic regression-multi-criteria evaluation consisting of a cellular automata Markovian hybrid model to predict land use patterns in 2030, and established a landscape index-based spatial conflict model to measure the evolutionary characteristics of spatial conflicts. Lin et al. [31] combined spatial conflict and landscape ecological indexes to measure the conflict level of the regional PLES and constructed a spatial configuration model based on a combination of multi-objective constraints and scenario settings to achieve optimization of the spatial layout. This paradigm is widely used owing to its ability to accurately identify the location of conflicts and reveal

regional ecological risks caused by irrational spatial land use structures [32]. Although many studies on the PLES exist, they focus on the types of land included in the PLES. Ecosystem optimization, including zoning and functional positioning of the national land space and the allocation of land resources such as landscape, water, forest, fields, lake, and grass is required [33,34]. Therefore, the characteristics of responses to the conflicts in the PLES and the laws governing ecological elements must be analyzed to understand the complex flow process of elements within the PLES.

Human activities and related land use changes are the main causes of accelerated soil erosion [35]. Irrational land use practices and reduction of surface vegetation cover have an amplifying effect on soil erosion [36]. Many studies have analyzed soil erosion in watersheds from the perspective of land use changes. Li et al. [37] found that the conversion of large areas of cropland to scrub caused the reduction of soil erosion in the watershed. The conversion of cropland to forest land and the reduction of bare land contribute to the reduction of soil erosion. The intensity of soil erosion increases significantly when woodland, scrub, and grassland are converted into cropland. Many scholars have discussed the reduction of soil erosion through ecological restoration programs, technologies, and soil management techniques [38]. Liu et al. [39] studied the impact of China's Return of Cropland to Forest Ecological Project in northern Shaanxi and suggested that the project effectively reduced soil erosion though the conversion of cropland to forest and grassland. Soil erosion occurs under the combined influence of factors such as rainfall, topography, and vegetation changes [40,41]. Thus, in addition to the effect of land change on soil erosion, other natural and socioeconomic factors must be considered, aiming to understand the relationship and process mechanism from the integrated perspective of land use change to ecological processes. Scholars have also researched soil erosion from the perspective of land conflicts. Valera et al. [42] found significant changes in soil properties and deterioration of soil fertility in hot spots of land conflict in the Uberaba River Basin, Brazil. Valle et al. [43] estimated that an area of 3.2–8.4% of a watershed on steep slopes that were suitable for forest or mixed forest-pastoral uses were vulnerable to soil erosion when they were used for other purposes. They proposed soil management strategies based on the distribution of areas at risk and emphasized the critical role of spatial control measures.

However, these studies on soil erosion do not explore changes in ecological elements resulting from spatial conflict in PLES, or their impacts on soil erosion. Therefore, based on the constraints and priorities described above, the question of this study is: How does soil erosion respond to spatial conflict in PLES and what are the natural and human disturbances that affect this response process? In this study, the Dongting Lake basin (DLB) in south-central China was analyzed to understand the response of soil erosion to spatial conflicts in PLES. The hilly red-soiled areas of southern China rank second after the Loess Plateau region in rate of soil erosion [44]. The objectives of this paper are to characterize the response of soil erosion in the DLB to PLES spatial conflict, and to explore the mechanism of the interaction between natural and socioeconomic factors in that response. The contribution of this paper is that it is the first exploration of the influence of PLES spatial conflicts on soil erosion in a watershed in the context of the PLES spatial system land management model, which can, to some extent, enrich our understanding of the ecological factors caused by PLES spatial conflicts. It can also provide a reference for the sustainable development of land use in the DLB and similar regions.

2. Materials and Methods

2.1. Study Area

The DLB in south-central China is situated between 24°38′–30°26′ N and 107°16′–114°17′ E, and is the second-largest freshwater lake in China. It is an important sub-basin of the middle reaches of the Yangtze River basin, covering most of Hunan Province in China and parts of Hubei Province, Guangxi Zhuang Autonomous Region, Guizhou Province, and Chongqing Municipality (Figure 1). The area of the watershed is approximately 2.67×10^5 km^2, accounting for 14% of the Yangtze River basin. The DLB consists of five

sub-basins: the Xiangjiang River Basin (XRB), Zishui River Basin (ZRB), Yuanjiang River Basin (YRB), Li River Basin (LRB) and Dongting Lake area (DLA). The upper, middle, and lower reaches of these sub-basins are hereafter indicated by using the prefixes U, M, and L, respectively; for example, for XRB, the sub-basins are UXRB, MXRB, and LXRB, respectively. The DLB consists of mountains in the west, hills and basins in the south-central part, and plains in the north. The region features a subtropical monsoon climate with an annual precipitation of 1300–1700 mm, with April–June accounting for approximately half of the annual precipitation [45]. The DLB has significant ecological functions and economic value, and plays an essential role in maintaining the ecological security of the Yangtze River basin. The Dongting Lake was designated as a national nature reserve by the State Council in 1994, and the East Dongting Lake wetlands, together with the West and South Dongting Lake wetlands, were included in the UNESCO List of Wetlands of International Importance in 1992 and 2001. The main land use types in the basin are forest and farmland. The DLB contains urban and rural populations of 30 million and 41 million, respectively [46]. In recent years, following the advancement of industrialization, urbanization, and agricultural modernization, unreasonable exploitation has caused serious degradation of local ecosystem services, conflicts between human and land, and increased risks to ecological security in the national space, resulting in challenges to the balance between natural ecosystems and sustainable economic and social development [47].

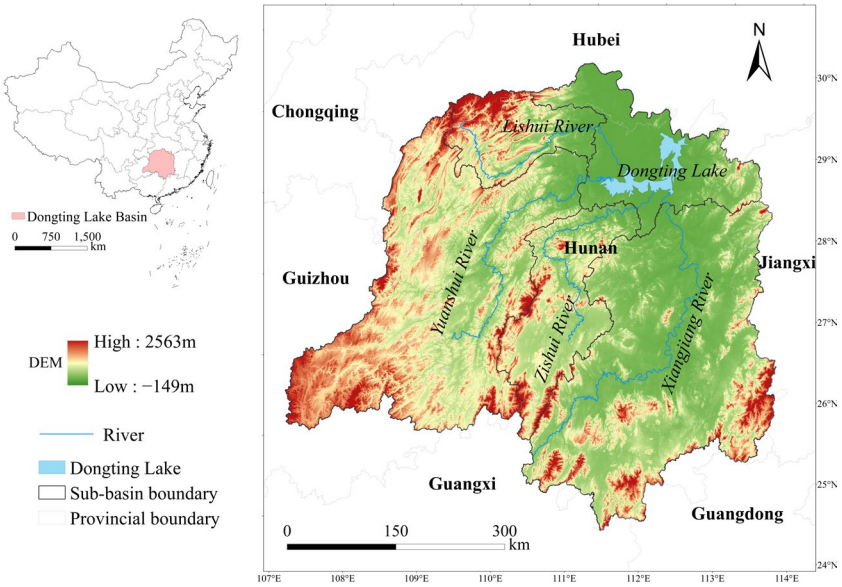

Figure 1. Study area.

2.2. Data Sources

Remote sensing monitoring data of land use status with a spatial resolution of 30 m for 2000, 2005, 2010, 2015 and 2018 were obtained from the Resource Environment Data Cloud Platform (http://www.resdc.cn/, accessed on 5 April 2022). Land cover types were classified into arable land, forest land, grassland, water, construction land, and unused land. Digital elevation model (DEM) data with a spatial resolution of 30 m were obtained from the geospatial data cloud platform (http://www.gscloud.cn/, accessed on 5 April 2022) and the sub-basins of the study area were extracted using ArcSWAT. Temperature and precipitation data from 52 meteorological stations in and around the study area were obtained from the National Meteorological Data Center (http://data.cma.cn/, accessed on 20 April 2022) and the National Earth System Science Data Center (http://www.geodata.cn/, accessed on 10 March 2022). Raster-based spatial distribution data were obtained by interpolating meteorological data from the meteorological stations using the Kriging spatial interpolation method. Normalized Difference Vegetation Index (NDVI) data were derived from the United States Geological Survey's MODIS vegetation index data product, MODI13Q1

(https://www.usgs.gov/, accessed on 27 November 2021) by processing mean values to synthesize annual mean values from 23 images for each year. Soil data were obtained using the Harmonized World Soil Database version 1.2 that was obtained from the China Qinghai-Tibet Plateau Scientific Data Center (http://www.tpdc.ac.cn/zh--hans/, accessed on 28 January 2022). GDP, population density, and other data were obtained from the Resource and Environment Data Cloud Platform (http://www.resdc.cn/, accessed on 21 March 2022).

2.3. Methods

2.3.1. Conflict Index of PLES

This paper adopts the land grouping method and combines the actual situation of the DLB to classify the PLES (Supplementary Table S1). The land grouping method is based on the principle that the dominant functional form of land use type is unique and stable [12].

The spatial conflict index of PLES was measured in terms of system complexity, vulnerability and stability as follows [48]:

$$SCCI = CI + VI - SI \tag{1}$$

where *SCCI* is the spatial conflict composite index, *CI* is the spatial complexity index, *VI* is the spatial vulnerability index, and *SI* is the spatial stability index.

(1) Complexity Index (*CI*). Human construction activities have made land use more complex and fragmented leading to increased conflict between ecological, production and living spaces. The area-weighted mean patch fraction dimension (*AWMPFD*) was used for land use classification patches to characterize the spatial complexity of the PLES, and the higher the value, the greater the degree of human interference [29]. The calculation is as follows:

$$AWMPFD = \sum_{n}^{m}\sum_{j=1}^{n}[\frac{2\ln(0.25P_{ij})}{\ln(a_{ij})}(\frac{a_{ij}}{A})] \tag{2}$$

where P_{ij} is the perimeter of the patch, a_{ij} is the area of the patch, A is the total area of the spatial type, ij is the j spatial type in the i spatial cell, m is the total number of spatial evaluation cells in the study area, and n is the total number of PLES spatial types.

(2) Vulnerability Index (*VI*). Land use system vulnerability is caused by the influence of external pressure, which varies at different stages. The landscape vulnerability index can be used to express the vulnerability of a land use system, which is an indicator of the response of land use spatial units to external pressure and land use processes. The calculation formula is as follows:

$$VI = \sum_{i=1}^{n} F_i \times \frac{a_i}{S} \tag{3}$$

where F_i is the vulnerability index of i spatial types, n is the total number of spatial types, and a_i is the area of each type of landscape within the unit, and S is the total area of the spatial unit. According to [48], the ranking of landscape vulnerability of F_i from strong to weak is: living space = 0.5, production space = 0.33, and ecological space = 0.17.

(3) Stability Index (*SI*). Empirical evidence reveals that the degree of spatial fragmentation of land use units is inversely proportional to their stability, with poorer stability indicating stronger conflict. Therefore, the degree of landscape fragmentation can be used to measure land use stability. The calculation is as follows:

$$SI = 1 - PD = 1 - \frac{n_i}{A} \tag{4}$$

where *PD* is the patch density, n_i is the number of patches of the i spatial type in each spatial unit, and A is the area of each spatial unit. The higher the *PD* value, the higher the

degree of spatial fragmentation, the lower the stability of the spatial landscape unit, and the lower the stability of the corresponding regional ecosystem.

Equation (5) is used to linearly standardize the numerical value in the above formula to the range of 0–1, to measure the spatial conflict.

$$S = \frac{X - X_{min}}{X_{max} - X_{min}} \tag{5}$$

where X is the value calculated based on Equations (2)–(4) above, X_{min} is the minimum value, and X_{max} is the maximum value. The spatial conflict comprehensive index is divided into five grades by the method of equal spacing: slight conflict (0–0.20), low conflict (0.21–0.4), moderate conflict (0.41–0.6), high conflict (0.61–0.8), and severe conflict (0.81–1).

To avoid excessive fragmentation of the spatial units in the study area, and considering factors such as research scale and scope, data type, patch status, and spatial resolution, a 3 × 3 km spatial grid was selected as the evaluation unit. Spatial patches that did not cover an entire grid square, near the boundaries of the study area were calculated as a complete square. The relevant landscape ecological index in each spatial unit was calculated to quantitatively assess the degree of spatial conflict.

2.3.2. Revised Universal Soil Loss Equation (RUSLE) Model

The RUSLE model was constructed on the basis of the USLE model through continuous revision. It was widely used for the quantitative measurement of soil erosion in watersheds [49]. The formula is as follows:

$$A = R \times K \times LS \times C \times P \tag{6}$$

where A is the actual average annual soil erosion modulus (t · hm^{-2} a^{-1}), R is the rainfall erosivity factor (MJ mm hm^{-2} h^{-1} a^{-1}), K is the soil erodibility factor (t hm^2 h hm^{-2} MJ^{-1} mm^{-1}), LS is the slope length and slope factor (dimensionless), C is the surface vegetation coverage and management factor (dimensionless), and P is the soil and water conservation measurement factor (dimensionless). For the calculation of each factor, please refer to [49]. Among these factors, P refers to the research results of scholars in southern China [50], in which forest land, grassland, and bare land are regarded as not subjected to soil conservation measures, and the value is 1; water bodies and constructed land generally do not cause soil erosion, and the value is 0; dry land is assigned a value of 0.4; and paddy field is assigned a value of 0.15.

According to the Technological Standard of Soil and Water Conservation (SL190–2007) issued by the Ministry of Water Resources of China, the soil erosion intensity in the DLB is divided into slight ($\leq$5 t · hm^{-2} a^{-1}), low (5–25 t · hm^{-2} a^{-1}), moderate (25–50 t · hm^{-2} a^{-1}), high (50–80 t · hm^{-2} a^{-1}), very high (80–150 t · hm^{-2} a^{-1}), and severe (>150 t · hm^{-2} a^{-1}).

2.3.3. Bivariate Spatial Autocorrelation Model

Spatial autocorrelation modeling is a spatial statistics method for testing the potential interdependence between geospatial elements and their neighboring spatial elements in a study area [51]. To investigate the spatial coupling characteristics of the spatial conflict index and soil erosion, a bivariate spatial analysis model was used to reflect the overall spatial association and variation using Moran's I index. The formula is as follows:

$$I_{sr} = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij} \left(\frac{y_{i,s} - y_s}{\sigma_s} \right) \left(\frac{y_{i,r} - y_r}{\sigma_r} \right)}{(n-1) \sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij}} \tag{7}$$

where I_{sr} is the bivariate global autocorrelation coefficient of the PLES spatial conflict index s and the soil erosion index r, $y_{i,s}$ and $y_{i,r}$ are the PLES spatial conflict indexes. Soil erosion in the i grid is subject to variances σ_s and σ_r.

For a comprehensive and specific reflection of the spatial correlation among the parts of the study area, local indicators of spatial association (LISA) were used to perform local spatial autocorrelation analysis to express local clustering and dispersion effects. Based on the spatial distribution relationships, four agglomeration patterns were defined: high-high (H-H), high-low (H-L), low-high (L-H) and low-low (L-L).

2.3.4. Optimal Parameter-based Geographical Detector (OPGD) Model

The Geodetector method is used to detect spatial heterogeneity, and reveal the driving factors underlying it [52]. The main idea is to divide the study space into sub-regions by variables, and compare the spatial variance within each sub-region and between different sub-regions to assess the decision power of potential explanatory variables [53]. A general geographic detector consists of four components, of which the core component is a factor detector that quantifies the relative importance of different geographic variables. The other three components are the interaction, risk, and ecological detectors. The formula is as follows:

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} = 1 - \frac{SSW}{SST} \quad (8)$$

where h denotes the stratification of the independent or dependent variable, N_h and N are the number of cells in stratum h and the whole domain, respectively, and σ_h^2 and σ^2 denote the variance of the dependent variable within stratum h and the whole domain, respectively. SSW and SST are the sum of within sum of squares and total sum of squares in the whole area, respectively.

In this model, spatial data discretization and spatial scale effects are fundamental issues, but previous studies have generally been determined empirically and lack accurate quantitative assessment. To solve this problem, Song et al. [54] proposed the OPGD model to achieve an optimal combination of spatial data discretization methods, spatial stratification interval numbers, and spatial scale parameters for a more accurate spatial analysis.

3. Results

3.1. Spatiotemporal Changes in the PLES Spatial Conflict

3.1.1. Changes in the PLES

The overall change in the PLES in the DLB from 2000 to 2018 can be obtained according to its classification (Figure S1). During the research period, the DLB was dominated by ecological space, which consistently remains at 69%, followed by production and living spaces. In terms of classification changes, ecological space shows a trend of first increasing and then decreasing, with an increase of 659.61 km^2 between 2005 and 2010, resulting from the conversion of a large area of grassland into woodland. The net conversion of grassland during this period amounted to 1308.94 km^2, of which 90% was converted to forest land in the northwestern and downstream areas of YRB and the upstream areas of XRB. Since the implementation of the "return of farmland to forest" policy, a large area of arable land has been converted to forest land, but urbanization reduced the conversion to forest land by nearly 40% in the later period. However, the ecological space decreased by 703.67 km^2 during 2010–2015 as a result of the conversion of 659.95 km^2 of forest land to construction land in the peripheral areas of towns in each watershed, especially in MXRB and LXRB. The production space has been decreasing, especially from 2005 to 2015, with a total reduction of 2475.26 km^2. During this period, as urbanization rapidly advanced, a large area of arable land was converted to construction land, most remarkably in MXRB and LXRB, around the Dongting Lake and in MZRB. By contrast, living space has been on the increase, increasing the most between 2005 and 2015, primarily due to large areas of arable land, forest land, and grassland being subjected to urban development. In general, the intensity of spatial transformation of the PLES in the DLB during the study period shows an inverted "U", in which the main feature is the transformation of ecological and productive spaces into living spaces, especially in the period 2005–2015, although this trend is weakening.

3.1.2. Changes in Spatial Conflict Index in the PLES

The overall spatial conflict index of the DLB shows an increasing trend followed by a decreasing trend (Figure 2). There was an increasing trend in the period 2000–2005 (conflict index of 0.409). During 2005–2010, the conflict was the most intense (0.411 in 2005 and 0.409 in 2010). After 2010, there was a decreasing trend (0.377 in 2015), but in 2018 there was a slight increase in the overall average conflict (0.380). Conflicts of moderate and above grades increased from 2000 to 2005, but later they gradually decreased from 54.57% in 2000 to 48.60% in 2018. The high conflict areas decreased each year during the study period. Conflict level escalation occurred from 2000 to 2010, accounting for 6.82%. The conflict level declined to 20.99% from 2005 to 2015 with the tradeoff between economic development and ecological protection occurring simultaneously in terms of PLES in the DLB. Remarkably, the proportion of conflict escalation then increased in the period 2015–2018. Approximately 45% of the DLB was consistently in moderate or higher conflict levels during the study period extending roughly along both sides of XRB with a tendency to shrink continuously. The center of gravity of the conflict was in LXRB, MZRB, UYRB, and southwestern part of the DLA. The spatial conflict index of PLES in the sub-basins is as follows in descending order: XRB, YRB, ZRB, LRB, and DLA. From 2000 to 2010, the main conflict areas were located in the UXRB, MXRB, LXRB, MZRB, the southwestern part of the DLA, the UYRB and the western scattered areas of YRB. A turning point in the conflict was reached in 2010, as all major conflict areas began to reduce, especially in MXRB, UXRB, and the LZRB.

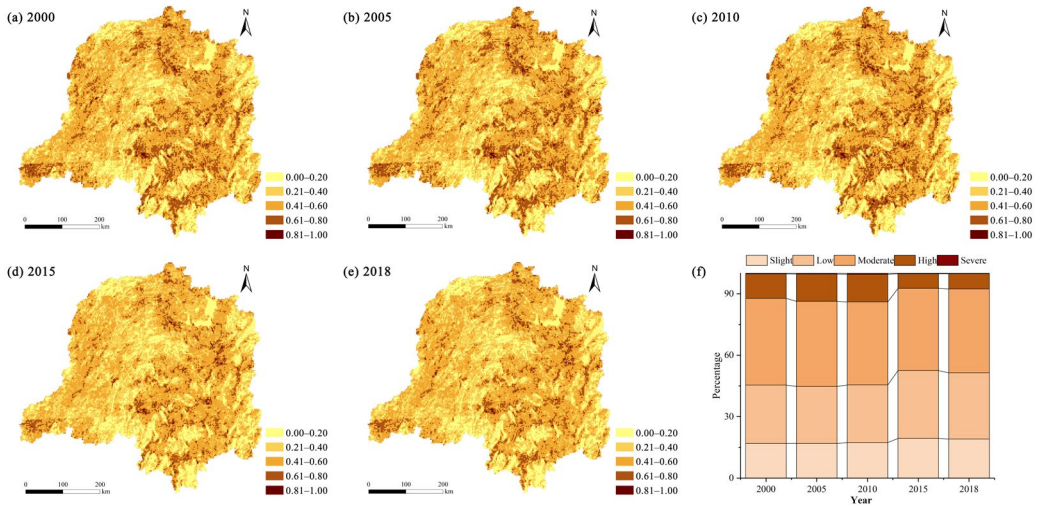

Figure 2. Distribution of spatial conflict of PLES in Dongting Lake Basin from 2000 to 2018: (**a**–**e**) patial conflict distribution, and (**f**) spatial conflict level proportions.

The trend of changing PLES is consistent with the trend of the conflict index, which shows an increasing trend and then a decreasing trend. Moderate and higher conflict levels during the study period were in the ecological space (approximately 20%), followed by the production space (approximately 30%), and the least was in the living space (Figure S2). The distribution of moderate conflicts in the production space decreased and then increased, while high and severe conflicts tended to decrease gradually. Although consistently low, the proportion of moderate and above conflict levels in the living space showed an increasing trend each year. In the ecological space, both moderate and high conflicts showed a decreasing trend each year, but they increased slightly in 2018; however, severe conflict levels showed a trend of increase followed by decrease.

3.2. Changes in Soil Erosion

The spatiotemporal distribution of the average soil erosion rate in the DLB in the period 2000–2018 was calculated using the RUSLE model (Figure 3). Temporal changes in the overall average soil erosion rate in the DLB showed a decreasing trend from

10.63 t · hm^{-2} a^{-1} in 2000 to 5.83 t · hm^{-2} a^{-1} in 2018. Mild erosion dominated the DLB during the study period at > 70% and increased each year. Excluding the rise in moderate erosion during 2000–2005, moderate and above soil erosion showed a decreasing trend from 11.27% in 2000 to 5.42% in 2018. The overall soil erosion rates in XRB, YRB, and ZRB were high, and the average annual erosion rates were lesser in LRB and DLA. The average soil erosion rates for the five sub-basins ranging from high to low were in YRB (10.47 t · hm^{-2} a^{-1}), ZRB (8.73 t · hm^{-2} a^{-1}), XRB (8.71 t · hm^{-2} a^{-1}), LRB (3.44 t · hm^{-2} a^{-1}), and DLA (2.02 t · hm^{-2} a^{-1}). The changes were more significant in XRB, YRB, and ZRB, of which the soil erosion in YRB, albeit the greatest, showed a decreasing trend each year during the study period, from 14.82 t · hm^{-2} a^{-1} in 2000 to 6.72 t · hm^{-2} a^{-1} in 2018. The overall erosion rates of XRB and ZRB showed an upward trend from 2000 to 2005, and decreased yearly after 2010. LRB showed a decreasing trend only after 2010, while the DLA always had low rates. Moderate and above soil erosion were distributed in the UYRB and western parts of UYRB and LYRB, MXRB, UXRB, UZRB, most of MLRB, LLRB, and ULRB. Soil erosion of moderate degree and above decreased significantly after 2010 and was the most obvious in UXRB, MZRB, and LZRB.

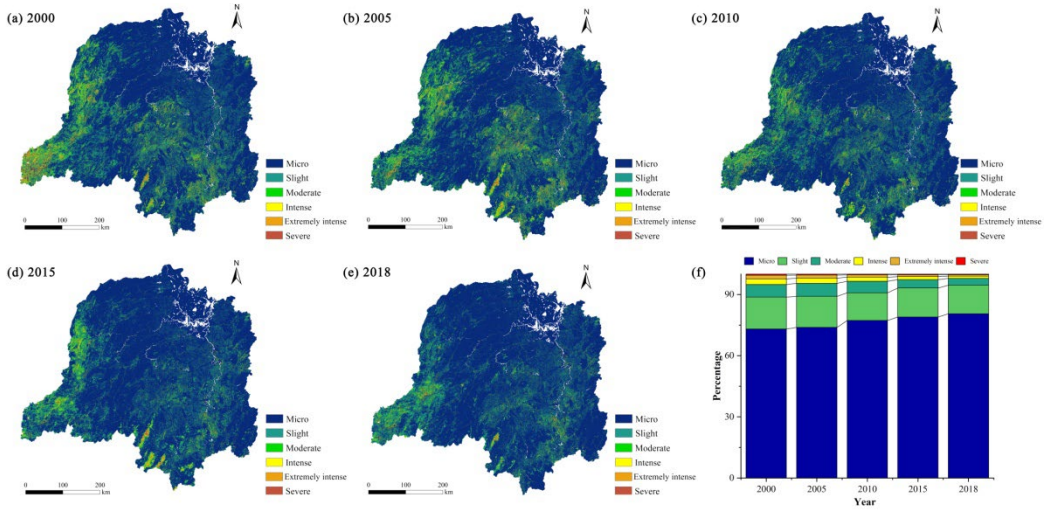

Figure 3. Spatial and temporal distribution of soil erosion in the Dongting Lake basin from 2000 to 2018: (**a**–**e**) soil erosion distribution, and (**f**) soil erosion class percentages.

3.3. Correlation between Spatial Conflicts and Soil Erosion

The correlation index of the spatial conflict of PLES and soil erosion in the DLB was calculated using the global spatial autocorrelation model and using Geoda software. The global Moran index was positive (confidence level < 0.001) (Table S2), and its overall trend was decreasing and then increasing, indicating a significant positive correlation between the probability of occurrence of soil erosion and spatial conflict in PLES. The correlation distribution between them was obtained using local spatial autocorrelation (Figure 4). The significance distribution of local spatial correlation is shown in Figure S3. Temporally, the agglomeration patterns H-H and L-H have an inverted "U" shape, whereas the high values appear in the period 2005–2010. H-L showed a gradual downward trend, with an overall decrease of 2.10%. L-L showed a decreasing trend throughout 2000–2015, but it slightly increased in 2018. Spatially, H-H is distributed in MYRB, UYRB, ULRB, LZRB, LXRB, and UXRB. Of these, the H-H in the downstream area of ZRB increased rapidly from 2000 to 2015 and in the urban area of Changsha–Zhuzhou–Xiangtan in XRB from 2015 to 2018; however, there was a slight decline in MYRB, UYRB, and ULRB, although the overall change was not significant. H-L was mainly distributed around the DLA and the downstream areas of LRB and YRB, with insignificant change from 2000 to 2005, and a decrease each year after 2010. L-H was mostly distributed in ULRB and UZRB and some

areas MXRB, with insignificant change overall. However, UYRB and some parts of MXRB presented a shift from L-H to H-H after 2010.

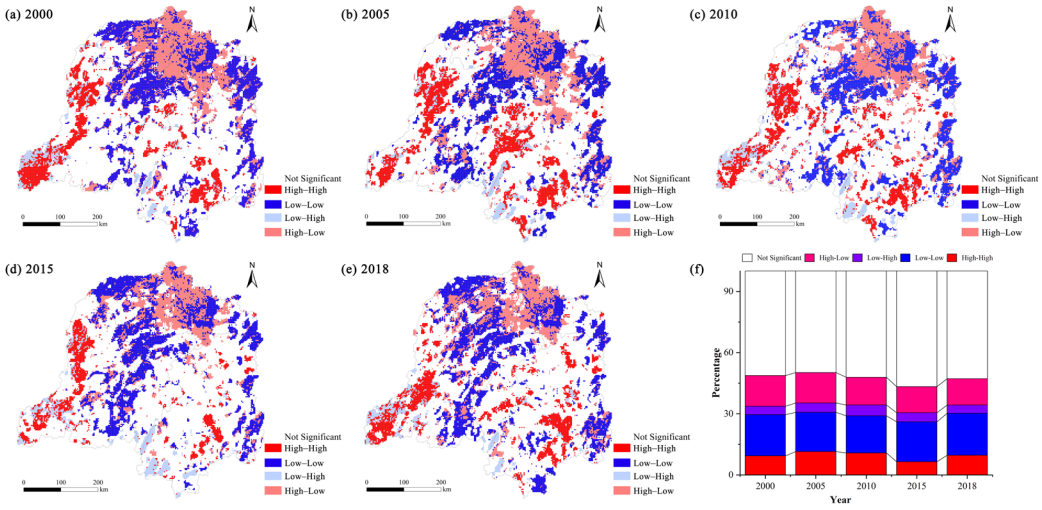

Figure 4. Local spatial autocorrelation between spatial conflict and soil erosion in the Dongting Lake Basin from 2000 to 2018: (**a**–**e**) local spatial correlation distribution, and (**f**) mode percentages.

3.4. Influencing Factors

The mechanism of soil erosion changes caused by the spatial conflict of PLES is complex. To further clarify the main influencing factors and mechanisms, DEM, slope, temperature, precipitation, NDVI, GDP, population density, urban expansion, rural expansion, and return of farmland to forest were analyzed. The OPGD model was used to detect and analyze these factors and the local spatial autocorrelation coefficients of spatial conflicts and soil erosion were treated as dependent variables. Since the explanatory strength of each driver for the correlation coefficients is strongly consistent during 2005–2015, an imputation analysis of the interaction influences using 2015 data as an example was performed. It was found that DEM and slope (natural factors) and GDP and population density (socioeconomic factors) have the greatest influence (Figure S4). These results are consistent with the study of Jiang et al. [24] in China, where population density had a positive effect on higher land use conflicts and elevation had a negative effect on lesser land use conflicts.

Figure 5 shows that the interaction between any two factors is stronger than a single factor in explaining the spatial correlation between spatial conflicts and soil erosion. These two-factor interactions are non-linearly and interactively enhanced, indicating a combined effect of several factors. Results of the analysis of interacting factors showed that DEM interacted strongly with GDP, NDVI, precipitation, population density, and fallow forest, followed by significant interactions between temperature and GDP, population density, NDVI, and precipitation.

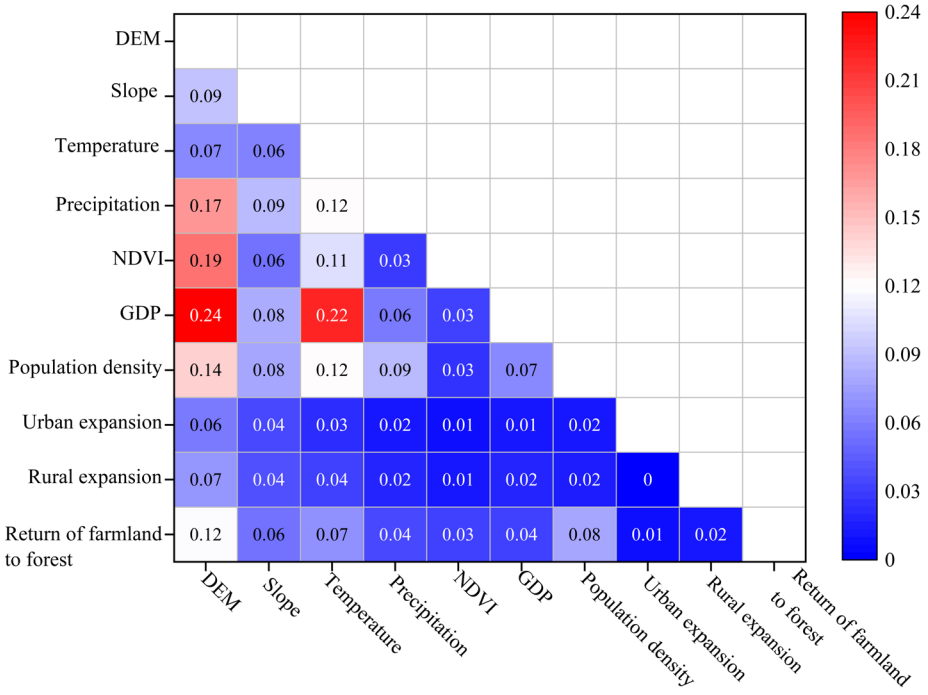

Figure 5. Results of the correlation analysis of interacting factors.

4. Discussion

4.1. Impact Mechanisms and Pathways

The spatial conflict among the PLES causes significant changes in the ecological environment, which is essentially a trade-off between ecological supply and socioeconomic developmental needs [13]. How to coordinate the relationship between the PLES to achieve the sustainable development of land and resource elements it carries has become a crucial scientific problem to be solved. Herein, for the first time, we focused on the impact of the PLES conflict on soil erosion in the watershed against the background of the PLES becoming an influential land space management theory and practice. The percentages of H-H during the study period were 9.40%, 11.48%, 10.81%, 6.51% and 9.63%, with an average contribution of soil erosion due to the spatial conflict of <10%; however, <10% of this area is distributed either in the middle or upper reaches of the sub-basins—which are important ecological conservation areas, or around urbanized areas such as the LZRB, MXRB, and LXRB. Moreover, UYRB and MXRB show a shift from L-H to H-H after 2010, indicating spatial conflicts are not the main causes of soil erosion and other factors may have been superimposed; however, they are essential for the future management of soil erosion or spatial control of PLES.

Results show, in most cases, soil erosion is not necessarily higher when conflict is higher; conversely, soil erosion is likely to be higher even when conflict is lower. This indicates the impact paths of different models contain disturbances from factors other than land changes. We focused on agglomeration patterns H-H, H-L, and L-H as these patterns imply a synergistic or mismatching effect between the spatial conflict of the PLES and soil erosion. The overall contributions of these patterns were 28.57%, 30.98%, 29.72%, 23.76%, and 26.56%, respectively, from 2000 to 2018, indicating that at least 27% of the area in the DLB needs to be traded off between the spatial conflict of PLES and soil erosion. Clearly, the driving mechanisms are different for different patterns, and the drivers are significantly different for different distribution areas of the same pattern. The distribution and changes of H-H showed an inverted "U" trend primarily in MYRB, ULRB, LZRB, UXRB, and LXRB. The reason for the high conflict and high erosion in MYRB, UYRB, ULRB, and UXRB is that these areas are located in the upper reaches of the sub-basins, and the intensity of human disturbance is not very strong when combined with the distribution

of population density, GDP, and urban land use. However, these areas have the natural drawback of large topographic differences, which combined with our geodetector results, give a slightly increased intensity to human disturbance caused by the change in land types under the effects of DEM, precipitation, and NDVI. Particularly, a change in ecological land use causes the risk of high intensity soil erosion, indicating that natural defects amplify the synergistic effect between them. Population growth within a spatial unit affects the intensity of conflict at high altitudes, and local natural conditions (e.g., topography) tend to affect conflict at the low altitudes [24]. We are concerned with the different degrees of reduction of H-H in these areas, notably in the upper reaches of the river, UXRB, and LZRB, benefiting from the implementation of the "return of farmland to forest" policy, which has an important mitigating effect on high conflict and erosion. By contrast, MXRB and LXRB, which also have H-H, have a flat topography and moderate precipitation in the basin, and the expansion of towns and villages result in high conflict and amplify soil erosion. Such a finding is consistent with most studies that show land use conflict occurs in the urban–rural transition zone, and rapid urban growth and water scarcity are the main causes [55].

H-L patterns are distributed around the DLA and downstream of the river and YRB. While these areas have a good level of urbanization and agricultural development and a medium level of precipitation for the basin, the high conflict has aggravated soil erosion, because of the natural advantage of a flat topography in offsetting the effect of intense human activity. Furthermore, its relatively stable spatial distribution shows that there is a strong dependence on natural advantages. It should be noted that the DLA has the highest proportion of production space in the whole DLB. Its arable land area accounts for 29.39% of the total arable land area in Hunan Province, with most of the arable land concentrated in flat land and a small amount in sloping land and terraced fields, among which the majority of the arable land has a slope of 2° or less. Although its advantages in topography largely alleviate the soil erosion caused by its high conflicts, those high conflicts remain a concern. On the one hand, it is one of the 12 most important commercial grain production bases in China. The development needs of urbanization and the policy of arable land protection must inevitably compete in a fierce game under the policy of strictest arable land protection and intensive utilization in China. The key to reducing spatial conflicts is to explore the green production potential of production space [56]. On the other hand, the historical accumulation of "occupation of lakes as fields" has led to a large reduction in the water area of the region and increased the intensity of human interference. In the long term, large-scale "returning fields to lakes" is an important policy trend in the region, but in the process of implementation, it is necessary to balance the intensive use of farmland and the connectivity of the watershed [57]. L-H is significantly distributed in ULRB, UZRB, and MZRB. Theoretically, without highly intense human disturbances in these areas, the probability of high soil erosion is low. However, our results contradict this hypothesis. For this reason, it is found that these areas are mostly located in mountainous and hilly areas with high DEM, and at the same time, the NDVI is also at the medium level for the basin, where high-intensity precipitation has a high probability of occurrence, particularly in UYRB. The path-dependence effect created by the three natural disadvantages causes high soil erosion. Significantly, we find that UYRB and some parts of MXRB show a shift from L-H to H-H after 2010, indicating the possibility of increased human activity. Therefore, in these areas, it is necessary to avoid the possible superimposed effects of high intensity human disturbances in the future.

4.2. Policy Implications

The global "land grab" driven by accelerated urbanization, industrialization, and agricultural expansion over the past decades has generated increasingly prominent land use conflicts in most parts of the world [58]. In particular, many developing countries are undergoing socioeconomic transformations that are likely to exacerbate land-use conflicts in the coming decades [59]. Accurately managing conflict zones and coordinating conflicts between spatial resource use and the ecological environment are essential to realize the

adaptability of land use functions and ecological capacity, which are critical for the sustainable development of land systems. As the world's largest developing country, China has set a common goal, between the government and academia, to achieve sustainable development of its land space, namely, intensive and efficient use of production space, livability and moderate size of living space, and undamaged and beautiful ecological space. This management model is an innovation based on the multifunctional theory of land [60]. The PLES approach is effective theoretically and practically for the spatial control of land against a background of the construction of an ecological civilization. It is foreseeable that this land management model will profoundly change the spatial state of China in the future. The DLB, selected for this paper, is a typical Great Lakes basin in China, and notably, often faces conflicts and challenges between environmental protection and socioeconomic development [61]. In particular, it is located in the red loam hilly region of southern China, a region with soil erosion second only to that of the Loess Plateau region [44]. Therefore, we use the DLB in China as an empirical study to reveal the response of soil erosion to spatial conflict in PLES and to explore the differences in the drivers of different models, which can provide a reference for the sustainable management of land systems in the DLB and also for similar basins in other countries around the world.

Our analysis of the changes in the distribution and driving mechanisms of the three types of agglomeration patterns (H-H, H-L, and L-H) suggests the need for differentiated governance paths for the different patterns. First, for the H-H concentration model, high conflict and erosion due to natural defects in MYRB, UYRB, ULRB, and UXRB are addressed. To avoid the expansion of human disturbance activities and simultaneously avoid falling into the "green trap," it is also necessary to explore the path of converting ecological resources into ecological capital to meet the needs of regional development [62]. For the MXRB and LXRB, where high erosion is caused by high intensity human disturbance, it is imperative to avoid the brutal expansion mode, and to achieve precise development based on the reasonable assessment of ecological risks to avoid the amplification effect of human disturbance on soil erosion. Second, H-L is primarily distributed around the DLA and downstream of the river and YRB. Although more active human activities do not lead to high erosion, the probability of high erosion occurring with climate change is not excluded. Therefore, it is recommended to avoid town or agricultural development exceeding ecological and environmental thresholds, while optimizing the structure of agricultural development, promoting large-scale operation, agglomeration of towns and villages, and reducing the risks that may arise from random development. Moreover, when human activities dominate, ecological restoration alone is inadequate to alleviate environmental problems, and new win-win paths must be explored in terms of economic development models. Third, L-H is predominantly distributed in ULRB, ZRB, and parts of MXRB. Natural disadvantages indicate that the disturbance of human activities must be reduced in these areas, while ecological restoration should be enhanced to compensate for the ecological disadvantages. Finally, from the perspective of the whole DLB, the breakdown of administrative boundaries is suggested to alleviate spatial conflicts among the PLES, and thus, reduce soil erosion from the aspect of preserving the integrity of the ecological unit. We are also concerned about the "rebound effect," which is a concept originally used in the field of economics to refer to the implementation of positive measures that do not bring positive effects as expected but instead produce bad results. We found a rebound effect in ecological space in the DLB, i.e., an increase in the total amount of overall ecological space, but no decrease in conflict. This is mostly related to the lack of consideration for the location and spatial distribution of the increased ecological space. Therefore, in the future, it will be essential to coordinate the systematic management of ecological elements in the watershed, and to carry out precisely-designed ecological projects or measures.

4.3. Future Research Prospects

While many studies have been performed on material flows in the earth system, this paradigm has not been applied to land system science. Particularly as land ecology is receiving increasing attention, there still seems to be a degree of fragmentation between material changes in land systems and macro-management. We have focused on the response of soil erosion to changes in the spatial conflict of the PLES. This recognizes the combination of change in physical property of land and spatial control, and the unification of micro and macro in the perspective of land system science. In this study, we have given prominence to the revelation of the mechanism of soil erosion within a PLES; however, certain shortcomings exist. First, the revelation of socioecological mechanisms between land use change and ecological problems needs to be more systematic. Although single ecological effects are of some significance, further clarification of the reciprocal feedback response mechanisms of land system changes to crucial ecological elements is needed in view of the systemic needs of future land management [63]. Second, the pathway to reveal the emergence mechanism needs to be clearer, i.e., the pathway of the change of ecological components to functional transformation and risk generation must be specifically quantified to provide a more scientific basis for macroscopic land system management [64]. Finally, further agent-based modeling approaches may be helpful to incorporate different types of subject behaviors into the construction of conflict indices, to refine the impact of attitudes or behaviors of key decision makers such as government, firms, and farmers [65,66].

5. Conclusions

Spatial conflict in PLES causes the deterioration of the ecological environment and reflects the imbalance between ecological supply and socioeconomic development. Identifying and controlling conflict zones in PLES and coordinating the conflicts between spatial resource utilization and ecological environment is required for the adaptation of the land use function and improving ecological capacity for the sustainable development of the land system. Considering the DLB as an example, we explored the response of soil erosion to the spatial conflict of the PLES, and revealed the driving factors and mechanisms of different patterns. Approximately 45% of the DLB is in moderate conflict, and the development of the watershed requires at least 27% of the area to be traded off between spatial conflict and soil erosion. Differences in the pathways of action among the factors were revealed through amplifying, mitigating, catalytic, and dependent effects that formed different patterns. We propose corresponding policy recommendations based on the differences in the driving mechanisms of the different patterns. Our research improves the understanding of the change pattern of ecological elements caused by the spatial conflict of the PLES and provides a reference for the adaptive path selection of land use and ecological restoration management in the DLB and similar regions.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/land11101794/s1, Table S1: Spatial classification system of PLES in Dongting Lake Basin; Table S2: Test results for global Moran's I; Figure S1: Spatial distribution of PLES in Dongting Lake Basin from 2000 to 2018; Figure S2: The area of each conflict level in the PLES from 2000 to 2018; Figure S3: Significance distribution of local spatial autocorrelation between spatial conflict and soil erosion in the Dongting Lake Basin from 2000 to 2018; Figure S4: Overall factor detection results from 2010 to 2015.

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References

1. Kuang, W. Issues regarding on spatial pattern change of national land space and its overall implementation on beautiful vision in new era. *Resour. Sci.* **2019**, *41*, 25–34. [CrossRef]
2. Peng, J.; Li, H.; Liu, Y.; Hu, Y.; Yang, Y. Identification and optimization of ecological security pattern in Xiong'an New Area. *Acta Geogr. Sin.* **2018**, *73*, 701–710. [CrossRef]
3. Fu, B. Several key points in territorial ecological restoration. *Bull. Chin. Acad. Sci.* **2021**, *36*, 64–69. [CrossRef]
4. Chen, M.; Liang, L.; Wang, Z.; Zhang, W.; Yu, J.; Liang, Y. Geographical thinking on the relationship between beautiful China and land spatial planning. *Acta Geogr. Sin.* **2019**, *74*, 2467–2481. [CrossRef]
5. Shen, Y.; Liu, T.; Zhou, P. Theoretical analysis and strategies of natural ecological space use control. *Chin. Land Sci.* **2017**, *31*, 17–24. [CrossRef]
6. Fang, C.; Yang, J.; Fang, J.; Huang, X.; Zhou, Y. Optimization Transmission Theory and Technical Pathways that Describe Multiscale Urban Agglomeration Spaces. *Chin. Geogr. Sci.* **2018**, *28*, 543–554. [CrossRef]
7. Liu, Y.; Wang, J. Theoretical analysis and technical methods of "multiple planning integration" in the rural to urban transition period in China. *Prog. Geogr.* **2016**, *35*, 529–536. [CrossRef]
8. Willemen, L.; Barger, N.N.; Brink, B.T.; Cantele, M.; Erasmus, B.F.N.; Fisher, J.L.; Gardner, T.; Holland, T.G.; Kohler, F.; Kotiaho, J.S.; et al. How to halt the global decline of lands. *Nat. Sustain.* **2020**, *3*, 164–166. [CrossRef]
9. Ouyang, W.; Skidmore, A.K.; Hao, F.; Wang, T. Soil erosion dynamics response to landscape pattern. *Sci. Total Environ.* **2010**, *408*, 1358–1366. [CrossRef]
10. Garcia-Ruiz, J.M.; Begueria, S.; Nadal-Romero, E.; Gonzalez-Hidalgo, J.C.; LanaRenault, N.; Sanjuan, Y. A meta-analysis of soil erosion rates across the world. *Geomorphology* **2015**, *239*, 160–173. [CrossRef]
11. Huang, A.; Xu, Y.; Lu, L.; Liu, C.; Zhang, Y.; Hao, J.; Wang, H. Research progress of the identification and optimization of production-living-ecological spaces. *Prog. Geogr.* **2020**, *39*, 503–518. [CrossRef]
12. Huang, J.; Lin, H.; Qi, X. A literature review on optimization of spatial development pattern based on ecological-production-living space. *Prog. Geogr.* **2017**, *36*, 378–391. [CrossRef]
13. Wang, D.; Jiang, D.; Fu, J.; Lin, G.; Zhang, J. Comprehensive assessment of production-living-ecological space based on the coupling coordination degree model. *Sustainability* **2020**, *12*, 2009. [CrossRef]
14. Zou, L.; Liu, Y.; Wang, J.; Yang, Y. An analysis of land use conflict potentials based on ecological-production-living function in the southeast coastal area of China. *Ecol. Indic.* **2021**, *122*, 107297. [CrossRef]
15. Liao, T.; Li, D.; Wan, Q. Tradeoff of exploitation-protection and Suitability evaluation of low-slope hilly from the perspective of "production-living-ecological" optimization. *Phys. Chem. Earth Parts A/B/C* **2020**, *120*, 102943. [CrossRef]
16. Chen, H.; Yang, Q.; Su, K.; Zhang, H.; Lu, D.; Xiang, H.; Zhou, L. Identification and optimization of production-living-ecological space in an ecological foundation area in the upper reaches of the Yangtze River: A case study of Jiangjin District of Chongqing. *Chin. Land Sci.* **2021**, *10*, 863. [CrossRef]
17. Feng, C.; Zhang, H.; Xiao, L.; Guo, Y. Land use change and its driving factors in the rural-urban fringe of Beijing: A production-living-ecological perspective. *Land* **2022**, *11*, 314. [CrossRef]
18. Li, C.; Wu, J. Land use transformation and eco-environmental effects based on production-living-ecological spatial synergy: Evidence from Shaanxi Province, China. *Environ. Sci. Pollut. Res. Int.* **2022**, *29*, 41492–41504. [CrossRef]
19. Yang, Q.; Duan, X.; Wang, L.; Jin, Z. Land use transformation based on ecological-production-living spaces and associated eco-environment effects: A case study in the Yangtze River Delta. *Sci. Geogr. Sin.* **2018**, *38*, 97–106. [CrossRef]
20. Zhang, X.; Xu, Z. Functional coupling degree and human activity intensity of production-living-ecological space in underdeveloped regions in China: Case study of Guizhou Province. *Land* **2021**, *10*, 56. [CrossRef]
21. Yang, Y.; Bao, W.; Liu, Y. Coupling coordination analysis of rural production-living-ecological space in the Beijing-Tianjin-Hebei region. *Ecol. Indic.* **2020**, *117*, 106512. [CrossRef]
22. Duan, Y.; Wang, H.; Huang, A.; Xu, Y.; Lu, L.; Ji, Z. Identification and spatial-temporal evolution of rural "production-living-ecological" space from the perspective of villagers' behavior—A case study of Ertai Town, Zhangjiakou City. *Land Use Policy* **2021**, *106*, 105457. [CrossRef]
23. Hui, E.C.M.; Bao, H. The logic behind conflicts in land acquisitions in contemporary China: A framework based upon game theory. *Land Use Policy* **2013**, *30*, 373–380. [CrossRef]
24. Jiang, S.; Meng, J.; Zhu, L.; Cheng, H. Spatial-temporal pattern of land use conflict in China and its multilevel driving mechanisms. *Sci. Total Environ.* **2021**, *801*, 149697. [CrossRef]
25. Zhou, D.; Lin, Z.; Lim, S. Spatial characteristics and risk factor identification for land use spatial conflicts in a rapid urbanization region in China. *Environ. Monit. Assess.* **2019**, *191*, 677–698. [CrossRef]

26. Jing, W.; Yu, K.; Wu, L.; Luo, P. Potential land use conflict identification based on improved multi-objective suitability evaluation. *Remote Sens.* **2021**, *13*, 2416. [CrossRef]
27. Fang, Y.; Ai, D.; Yang, Y.; Sun, W.; Zu, J. Multi-objective spatial suitability evaluation and conflict optimization considering productivity, sustainability, and livability in southwestern mountainous areas of China. *Sustainability* **2021**, *14*, 371. [CrossRef]
28. Dong, G.; Ge, Y.; Jia, H.; Sun, C.; Pan, S. Land use multi-suitability, land resource scarcity and diversity of human needs: A new framework for land use conflict identification. *Land* **2021**, *10*, 1003. [CrossRef]
29. Liao, L.; Dai, W.; Chen, J.; Huang, W.; Jiang, F.; Hu, Q. Spatial conflict between ecological-production-living spaces on Pingtan Island during rapid urbanization. *Resour. Sci.* **2017**, *39*, 1823–1833. [CrossRef]
30. Wang, Q.; Wang, H. Dynamic simulation and conflict identification analysis of production-living-ecological space in Wuhan, Central China. *Integr. Environ. Assess. Manag.* **2022**. Available online: https://setac.onlinelibrary.wiley.com/doi/full/10.1002/ieam.4574 (accessed on 10 January 2022). [CrossRef]
31. Lin, G.; Jiang, D.; Fu, J.; Cao, C.; Zhang, D. Spatial conflict of production-living-ecological space and sustainable-development scenario simulation in Yangtze River Delta Agglomerations. *Sustainability* **2020**, *12*, 2175. [CrossRef]
32. Liu, X.; Zhang, Z.; Li, M.; Fu, Y.; Hui, Y. Spatial conflict simulation of land-use based on human-land-landscape elements inter coordination: A case study in Tianjin, China. *Environ. Monit. Assess.* **2022**, *194*, 317. [CrossRef]
33. Cao, Y.; Wang, J.; Li, G. Ecological restoration for territorial space: Basic concepts and foundations. *Chin. Land Sci.* **2019**, *33*, 1–10. [CrossRef]
34. Lin, J.; Liu, S.; Liu, S. Region-element coordination: The critical issue concerning the construction of the system for developing and protecting territorial space. *Chin. Land Sci.* **2018**, *32*, 1–7. [CrossRef]
35. Pandey, S.; Kumar, P.; Zlatic, M.; Nautiyal, R.; Panwar, V.P. Recent advances in assessment of soil erosion vulnerability in a watershed. *Int. Soil Water Conse.* **2021**, *9*, 305–318. [CrossRef]
36. Borrelli, P.; Robinson, D.A.; Fleischer, L.R.; Lugato, E.; Ballabio, C.; Alewell, C.; Meusburger, K.; Modugno, S.; Schütt, B.; Ferro, V.; et al. An assessment of the global impact of 21st century land use change on soil erosion. *Nat. Comm.* **2017**, *8*, 1–13. [CrossRef]
37. Li, T.; Liu, K.; Ma, L.; Bao, Y.; Wu, L. Evaluation on soil erosion effects driven by land use changes over Danjiang River basin of Qinling Mountain. *J. Nat. Resour.* **2016**, *31*, 583–595. [CrossRef]
38. Wen, X.; Zhen, L. Soil erosion control practices in the Chinese Loess Plateau: A systematic review. *Environ. Dev.* **2020**, *34*, 100493. [CrossRef]
39. Liu, W.; Liu, J.; Kuang, W. Spatiotemporal patterns of soil protection effect of the Grain for Green Project in northern Shaanxi. *Acta Geogr. Sin.* **2019**, *74*, 1835–1852. [CrossRef]
40. Sharma, A.; Tiwari, K.N.; Bhadoria, P.B.S. Effect of land use land cover change on soil erosion potential in an agricultural watershed. *Environ. Monit. Assess.* **2011**, *173*, 789–801. [CrossRef]
41. Devátý, J.; Dostál, T.; Hösl, R.; Krása, J.; Strauss, P. Effects of historical land use and land pattern changes on soil erosion—Case studies from Lower Austria and Central Bohemia. *Land Use Policy* **2019**, *82*, 674–685. [CrossRef]
42. Valera, C.A.; Valle Junior, R.F.; Varandas, S.G.P.; Sanches Fernandes, L.F.; Pacheco, F.A.L. The role of environmental land use conflicts in soil fertility: A study on the Uberaba River basin, Brazil. *Sci. Total. Environ.* **2016**, *562*, 463–473. [CrossRef] [PubMed]
43. Valle Junior, R.F.; Varandas, S.G.P.; Sanches Fernandes, L.F.; Pacheco, F.A.L. Environmental land use conflicts: A threat to soil conservation. *Land Use Policy* **2014**, *41*, 172–185. [CrossRef]
44. Chen, J.; Li, Z.; Xiao, H.; Ning, K.; Tang, C. Effects of land use and land cover on soil erosion control in southern China: Implications from a systematic quantitative review. *J. Environ. Manag.* **2021**, *282*, 111924. [CrossRef]
45. Geng, M.; Li, F.; Gao, Y.; Li, Z.; Chen, X.; Deng, Z.; Zou, Y.; Xie, Y.; Wang, Z. Wetland Area Change from 1986–2016 in the Dongting Lake Watershed at the Sub-Watershed Scale. *Pol. J. Environ. Stud.* **2021**, *30*, 1611–1620. [CrossRef]
46. Zhang, X.; Liu, M. Assessing the spatial and temporal patterns of seasonal precipitation extremes and the potential influencing factors in Dongting Lake Basin, China. *Water* **2016**, *8*, 558. [CrossRef]
47. Wang, L.; Li, Z.; Wang, D.; Chen, J.; Liu, Y.; Nie, X.; Zhang, Y.; Ning, K.; Hu, X. Unbalanced social-ecological development within the Dongting Lake basin: Inspiration from evaluation of ecological restoration projects. *J. Clean. Prod.* **2021**, *315*, 128161. [CrossRef]
48. Zhou, D.; Xu, J.; Wang, L. Land use spatial conflicts and complexity: A case study of the urban agglomeration around Hangzhou Bay, China. *Geogr. Res.* **2015**, *34*, 1630–1642. [CrossRef]
49. Xiao, J.; Xie, B.; Zhou, K.; Shi, S.; Li, J.; Yang, M.; Liu, C. Assessment of soil erosion in the Dongting Lake Basin, China: Patterns, drivers, and implications. *PLoS ONE* **2021**, *16*, e0261842. [CrossRef]
50. Qian, Q.; Wang, S.; Bai, X.; Zhou, D.; Tian, Y.; Li, Q.; Wu, L.; Xiao, J.; Zhou, C.; Chen, F. Assessment of soil erosion in karst critical zone based on soil loss tolerance and source-sink theory of positive and negative terrains. *Acta Geogr. Sin.* **2018**, *73*, 2135–2149. [CrossRef]
51. Cheng, Z. The spatial correlation and interaction between manufacturing agglomeration and environmental pollution. *Ecol. Indic.* **2016**, *61*, 1024–1032. [CrossRef]
52. Wang, J.; Xu, C. Geodetector: Principle and prospective. *Acta Geogr. Sin.* **2017**, *72*, 116–134. [CrossRef]
53. Wang, J.; Zhang, T.; Fu, B. A measure of spatial stratified heterogeneity. *Ecol. Indic.* **2016**, *67*, 250–256. [CrossRef]

54. Song, Y.; Wang, J.; Ge, Y.; Xu, C. An optimal parameters-based geographical detector model enhances geographic characteristics of explanatory variables for spatial heterogeneity analysis: Cases with different types of spatial data. *GISci. Remote Sens.* **2020**, *57*, 593–610. [CrossRef]
55. Jiang, S.; Meng, J.; Zhu, L. Spatial and temporal analyses of potential land use conflict under the constraints of water resources in the middle reaches of the Heihe River. *Land Use Policy* **2020**, *97*, 104773. [CrossRef]
56. Zheng, H.; Peng, J.; Qiu, S.; Xu, Z.; Zhou, F.; Xia, P.; Adalibieke, W. Distinguishing the impacts of land use change in intensity and type on ecosystem services trade-offs. *J. Environ. Manag.* **2022**, *316*, 115206. [CrossRef]
57. Yang, F.; Ouyang, J.; Duan, N.; Zhao, Z. Spatial-temporal evolution and economic driving analysis of water network pattern in Dongting Lake Basin from 1990 to 2020. *Econ. Geogr.* **2022**, *42*, 188–197. [CrossRef]
58. Dietz, K.; Engels, B. Analysing land conflicts in times of global crises. *Geoforum* **2020**, *111*, 208–217. [CrossRef]
59. Bao, W.; Yang, Y.; Zou, L. How to reconcile land use conflicts in mega urban agglomeration? A scenario-based study in the Beijing-Tianjin-Hebei region, China. *J. Environ. Manag.* **2021**, *296*, 113168. [CrossRef]
60. Lin, G.; Fu, J.; Jiang, D. Production-living-ecological conflict identification using a multiscale integration model based on spatial suitability analysis and sustainable development evaluation: A case study of Ningbo, China. *Land* **2021**, *10*, 383. [CrossRef]
61. Albert, J.S.; Destouni, G.; Duke- Sylvester, S.M.; Magurran, A.E.; Oberdorff, T.; Reis, R.E.; Winemiller, K.O.; Ripple, W.J. Scientists' warning to humanity on the freshwater biodiversity crisis. *Ambio* **2021**, *50*, 85–94. [CrossRef]
62. Cumming, G.S.; Buerkert, A.; Hoffmann, E.M.; Schlecht, E.; von Cramon-Taubadel, S.; Tscharntke, T. Implications of agricultural transitions and urbanization for ecosystem services. *Nature* **2014**, *515*, 50–57. [CrossRef]
63. Fu, B.; Liu, Y.; Wang, C.; Li, C.; Jiang, W.; Hua, T.; Zhao, W. The research priorities of Resources and Environmental Sciences. *Geogr. Sustain.* **2021**, *2*, 87–94. [CrossRef]
64. Klein, B.; Hoel, E. The emergence of informative higher scales in complex networks. *Complexity* **2020**, 8932526. [CrossRef]
65. Arneth, A.; Brown, C.; Rounsevell, M.D.A. Global models of human decision making for land-based mitigation and adaptation assessment. *Nat. Clim. Chang.* **2014**, *4*, 550–557. [CrossRef]
66. Ali, S.; Xu, H.; Xu, P.; Ahmed, W. Evolutional attitude based on option prioritization for conflict analysis of urban transport planning in Pakistan. *J. Syst. Sci. Syst. Eng.* **2019**, *28*, 356–381. [CrossRef]