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Spatial and Temporal Evolution of Ecosystem Service Value in Shaanxi Province against the Backdrop of Grain for Green

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Abstract: The Grain for Green Project (GGP) has influenced Shaanxi Province's land-use pattern, resulting in a shift in ecosystem service value (ESV). Exploring the spatial and temporal evolution of the pattern of land use and ESV in Shaanxi Province, before and after the project's implementation, can give a theoretical foundation for regional land-use planning. For this study, we used the transfer matrix and the value equivalent approaches to investigate the influence of project implementation on the spatial distribution and evolution of patterns of land use and ESV in Shaanxi Province based on four periods of land-use data from 1990 to 2020. The results suggest the following: (1) Farmland, forestland, and grassland were the most common land-types in Shaanxi Province. Farmland, forestland, and grassland in Shaanxi Province were all altered dramatically over the research period due to the GGP. Farmland was turned mostly into forestland and grassland, and forestland and grassland areas progressively grew. (2) The ESVs in Shaanxi Province were USD 3802.82, 3814.90, 3836.20, and 3806.50 billion in 1990, 2000, 2010, and 2020, respectively. The most value was supplied by hydrological management, while water resources provided the lowest value. Forestland and grassland were the most valuable land-types in high-value locations, whereas built-up land was the most valuable land-type in low-value areas. (3) While the GGP has increased the ESV of forestland and grassland, it has harmed the acreage of other land-types, resulting in a decline in the total ESV in Shaanxi Province.

Keywords: land use; ecosystem service value; Grain for Green Project; Shaanxi Province

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1. Introduction

Ecosystem services (ESs) are products and services which ecosystems and ecological processes generate, and which are essential for human survival. According to the Millennium Ecosystem Assessment methodology, ESs are divided into 4 categories—provisioning services, regulating services, support services and cultural services, which are further classified into 11 categories [1–3]. Human disruption of the ecosystem is becoming more common as the economy and urbanization develop. The question of conserving the environment while increasing its supply has become a global issue [4–7].

Ecosystem Service Value (ESV) is a value expression of ecosystem function utility that refers to the value of life-support products and services provided directly or indirectly through the structure, process, and function of the ecosystem. Measuring the quality of regional ecological environments and achieving sustainable development is essential [8–10]. Land-use change is the most immediate expression of human activity impacting the ecosystem. It is a critical aspect of the evolution of ESs, and it plays a crucial role [11,12]. Quantitative ESV can better evaluate and reflect the impact of regional land-use change on ecosystem services and provide an essential basis for ecological environment protection and ecological compensation decision-making. At the same time, optimizing the land-use structure and promoting regional sustainable development are crucial [9,10,13,14].

Since Costanza et al. [3] completed quantitative monetization assessments of ESs, the ESV has received much attention [4,5,15–18]. Sannigrahi et al. [9] discovered that decreases in forestland, wetland, and water areas, along with the expansion of built-up land, has resulted in a considerable decline in global ESs by measuring the global ESV and its response to land-use change from 1995 to 2015. Rahman et al. [19] examined the effect of land-use and land-cover changes on the value of urban ESs in Dhaka, Bangladesh. They discovered that the growth of built-up land came at the expense of farmland, forestland, and water areas, and the regional ESV continued to decline. Based on Costanza's evaluation model, Xie et al. [20,21] revised and improved the ESV equivalent-per-unit area according to the actual situation in China, which was then applied to the study of ESV on different scales by many scholars [7,22–25].

The Chinese government has adopted several ecological restoration initiatives and environmental protection programs, such as the Grain for Green Project (GGP) [26,27] and the Natural Forest Protection Project [28,29], to enhance the regional ecological environment. As the largest ecological restoration project in the world, the GGP can alleviate the contradiction between the ecological environment and human activities by changing land-use types and landscape patterns and repairing ecosystem service functions and structures [30–33]. To evaluate the effects of GPP, several scholars conducted numerous tests and provided discussions on grain production [34,35], soil carbon sequestration capacity [36], ESV [37,38], land use [39,40], vegetation change [41], and other aspects. Evaluating the implementation effect of the GGP from the perspective of the ESV can provide scientific and reasonable policy suggestions for further project implementation.

The ecological environment of Shaanxi Province is fragile, and soil erosion is severe; it is the most crucial implementation area for the GGP. In recent decades, the land use of Shaanxi Province has undergone tremendous changes. Current research work in this area examines the tradeoff and synergy between ecosystem services [27] and changes in vegetation ecosystem services [42]. Previous studies have mainly focused on spatial and temporal distributions, but they have lacked analyses of changes in ESV from before and after the implementation of the project. Therefore, in this study, based on the land-use data for 1990, 2000, 2010, and 2020, we have evaluated the land use and ESV from prior to and after project implementation (1990–2000 and 2000–2020), thus revealing the project's impact. Our objectives were to (1) assess the spatial and temporal dynamics of land use and ESV prior to and after the implementation of the project; (2) reveal the impact of project implementation on land use and ESV; and (3) provide reasonable suggestions for the future implementation of the project.

2. Materials and Methods

2.1. Study Area

Shaanxi Province, located in China's central and western regions, is situated between 105°29′~111°15′ E and 31°42′~39°35′ N, spanning the Yellow and Yangtze River basins, and covering an area of about 20.56×10^6 ha (Figure 1). The north and south are narrow and long, with distinct climates and landforms. The landforms in the north are mostly plateaus and plains, whereas the south is mostly hilly. It is divided into three climatic zones: a temperate, semi-arid or semi-humid climate in the north; a temperate, semi-humid climate in the center; and a temperate, humid climate in the south. According to its unique natural conditions, the province's 10 prefecture-level cities can be divided between 3 regions: the northern Shaanxi Loess Plateau (Yulin and Yan'an), the Guanzhong Plain (Baoji, Xianyang, Xi'an, Tongchuan, and Weinan), and the southern Shaanxi Qinba Mountainous Region (Hanzhong, Ankang, and Shangluo). Among China's provinces, Shaanxi Province has severe soil erosion and a fragile ecological environment. As one of the earliest pilot provinces to implement the GGP, Shaanxi Province has achieved some results [43,44].

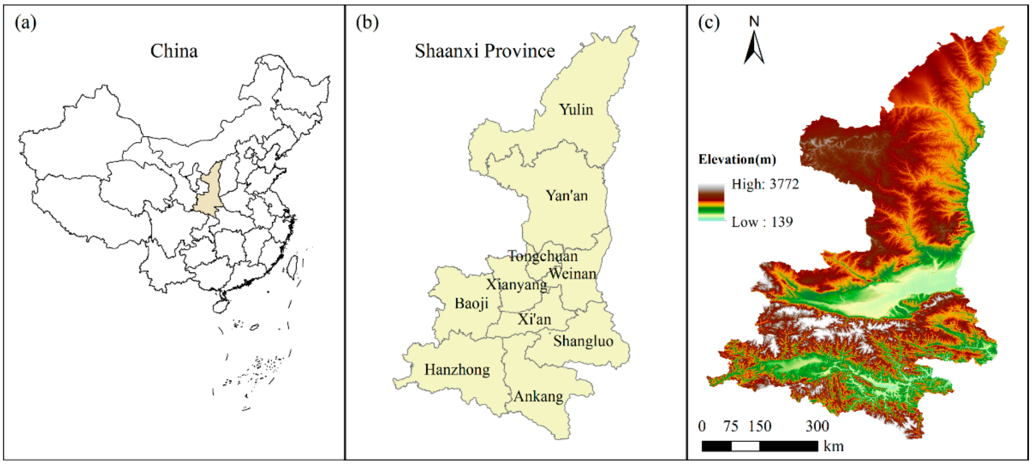

Figure 1. Location of Shaanxi Province, China: (**a**) Map of China; (**b**) 10 prefecture-level cities of Shaanxi Province; (**c**) Digital elevation model (DEM).

2.2. Data Sources

The land-use data (30 m $\times$ 30 m) and DEM data (30 m $\times$ 30 m) for Shaanxi Province in 1990, 2000, 2010, and 2020 were all obtained from the Resource and Environmental Science Data Center (http://www.resdc.cn, accessed on 9 April 2022). Land-use data were generated by manual visual interpretation with Landsat TM/ETM as the primary information source. Combined with the national land-use classification standards and research needs, land-use types were divided into six first-level land-use types: farmland, forestland, grassland, water areas, built-up land, and barren land. The average grain yield data of Shaanxi Province were obtained from *Shaanxi Statistical Yearbook*, and other socio-economic statistics were obtained from the national compilation of agricultural product cost–benefit data.

2.3. Research Methods

2.3.1. Land-Use Dynamic Degree

A single land-use dynamic degree can represent the dynamic change in land-use types in the research region by quantitatively describing the speed and amplitude of change in distinct land-use types across time [45]. The formula for the computation is as follows:

$$K = \frac{S_b - S_a}{S_a} \times \frac{1}{T} \times 100\% \quad (1)$$

where K represents the dynamic degree of a certain land-use type during the study period; S_b and S_a represent the areas of a certain land-use type at the end and the beginning of the study, respectively; and T reflects the length of the research period (in years).

2.3.2. Land-Use Transfer Matrix

A transfer matrix is used to quantitatively describe the number and direction of mutual transformations between different land-types, revealing the dynamic change process of different land-types during different periods. The formula for the computation is as follows:

$$S_{ij} = \begin{bmatrix} S_{11} & \cdots & S_{1n} \\ \vdots & \ddots & \vdots \\ S_{n1} & \cdots & S_{nn} \end{bmatrix} \quad (2)$$

where S_{ij} represents the change in land-type from the beginning to the end of the research period and n represents the number of land-types.

2.3.3. Calculation of the ESV

Costanza et al. [3] proposed an ESV measurement method. Xie et al. [21] developed China's ESV equivalent factor table based on this method and China's actual situation. The ESV of a standard equivalent factor is defined as the value of grain production per unit area (ha) of the farmland ecosystem. In this study, through consultation with the *China Statistical Yearbook*, the *Shaanxi Statistical Yearbook*, and the compilation of cost–benefit data of agricultural products in China during the study period, the average grain price in Shaanxi Province was USD 0.311 per kg^{-1}, and the average yield was 3626.94 kg per ha^{-1}. Referring to the study by Li et al. [46], the equivalent factor was modified, and the equivalent factor of the ESV of a standard unit in Shaanxi Province during the study period was USD 179.22 per ha^{-1}. Then, the ESV coefficient of each land-use type in Shaanxi Province was obtained (Table 1).

Table 1. Value coefficients of land ecosystem services in Shaanxi Province (USD ha^{-1}).

Ecosystem Services		Farmland	Forestland	Grassland	Water Areas	Built-Up Land	Barren Land
Provisioning services	Food production	179.86	41.10	37.98	130.21	45.57	0.81
	Raw materials	39.88	94.40	55.88	37.44	48.83	2.44
	Water supply	−212.41	48.83	30.93	1349.34	−603.87	1.63
Regulating services	Gas regulation	144.86	310.48	196.41	125.33	0	10.58
	Climate regulation	75.69	928.99	519.23	372.74	0	8.14
	Environment purification	21.97	272.23	171.45	903.36	−400.41	33.37
	Hydrological regulation	243.34	607.93	380.33	16,641.30	−870.80	19.53
Support services	Soil conservation	86.64	378.03	239.27	151.37	3.26	12.21
	Nutrient cycle maintenance	25.23	28.89	18.45	11.39	0	0.81
	Biodiversity maintenance	27.67	344.25	217.57	415.06	55.34	11.39
Cultural services	Aesthetic landscape	12.21	150.97	96.03	307.63	195.32	4.88

3. Results

3.1. Land-Use Change and Spatial Characteristics

3.1.1. Land-Use Change Analysis

The land-use change in Shaanxi Province from 1990 to 2020 is shown in Table 2 and Figure 2. The main land-use types in Shaanxi Province during the study period were grassland, accounting for about 37% of the total study area; farmland, accounting for about 35%; and forestland, accounting for about 22%. Water areas, built-up land, and barren land accounted for the smallest percentages, and the total proportion of these 3 types was about 5%. Based on the land-use change and the proportion of various land-types, farmland was in a dynamic increase process prior to the implementation of the project, and it has been in a reduction process since implementation. The ratio of cultivated land to the total area decreased from 35% in 1990 to 32% in 2020. Forestland was in a dynamic increase process prior to the implementation of the project, with a slight growth rate. Since the implementation of the project, it has been in a state of growth; the change was large, with the proportion increasing from 22% in 1990 to 25% in 2020. The size of the grassland area was directly affected by the project implementation, and the overall change was small, but it is in a state of fluctuation. The project implementation had little influence on the water areas, and the overall change was small, with the total proportion being maintained at 1%. The most noticeable dynamic shift in built-up land was due to the acceleration of urbanization, which resulted in a massive increase in built-up land from 1% in 1990 to 3% in 2020. With the implementation of the project and urbanization, more and more land has undergone development and utilization, resulting in a gradual reduction in barren-land areas during the study period.

Table 2. Land-use change in Shaanxi Province from 1990 to 2020.

Land-Use Types	Area (ha)				Change Rates (%)			
	1990	2000	2010	2020	1990–2000	2000–2010	2010–2020	1990–2020
Farmland	7,182,895	7,196,119	6,826,601	6,666,814	0.02 ↑	−0.51 ↓	−0.23 ↓	−0.18 ↓
Forestland	4,616,388	4,635,906	4,803,465	4,833,057	0.04 ↑	0.36 ↑	0.06 ↑	0.12 ↑
Grassland	7,715,601	7,777,948	7,889,430	7,836,053	0.08 ↑	0.14 ↑	−0.07 ↓	0.04 ↑
Water areas	186,686	181,408	180,463	178,801	−0.28 ↓	−0.05 ↓	−0.09 ↓	−0.11 ↓
Built-up land	276,517	315,211	430,337	527,762	1.40 ↑	3.65 ↑	2.26 ↑	2.27 ↑
Barren land	615,548	487,051	463,445	447,936	−2.09 ↓	−0.48 ↓	−0.33 ↓	−0.68 ↓

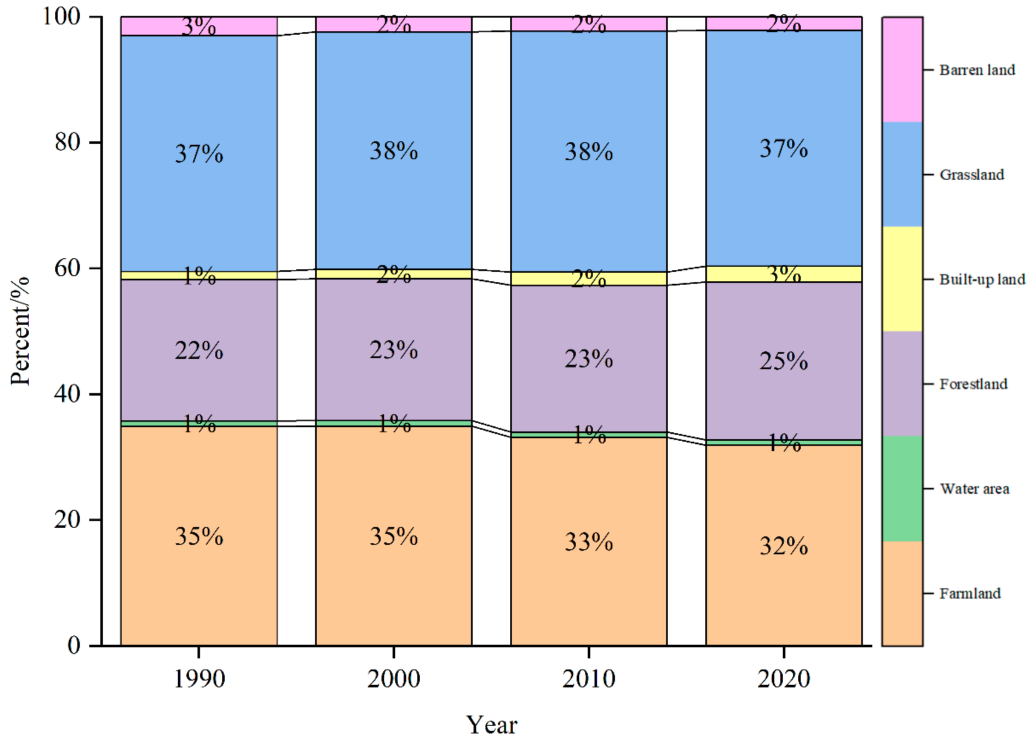

Figure 2. Proportions of land-use types in Shaanxi Province from 1990 to 2020.

From the perspective of spatial change, farmland is mainly concentrated in the central region (Figure 3). With the implementation of the project and urbanization, farmland showed a decreasing trend. Forestland showed an increasing trend, concentrated in southern Shaanxi and the central mountainous areas. Grassland is in a dynamic process, mainly distributed in northern Shaanxi. Water areas are relatively modest, with little change, and are primarily spread along rivers. Barren land is primarily dispersed in northern Shaanxi's sandy area and has been steadily shrinking since the project was implemented. The most visible trend is the increase in built-up land centered in central Shaanxi Province and the cities' core regions. Built-up land is encroaching into farmland, grassland, and forestland around cities and rural regions, linked to urban population increases and accelerated urbanization.

3.1.2. Characteristics of Land-Use Transfer Analysis

The land-use transfer matrix method was used to analyze changes in land-use types prior to and after the implementation of the project, yielding 2 land-use transfer matrix tables, representing 1990–2000 and 2000–2020, respectively (Tables 3 and 4). With 2000 as the dividing point, the transfer-in and transfer-out of land-use types changed considerably.

From 1990 to 2000, the area of farmland converted to grassland in Shaanxi Province was the largest, at 55,325.07 ha, followed by built-up land that was converted to farmland and forestland that was converted to grassland, at 35,707.32 ha and 25,334.28 ha, respectively. Between 2000 and 2020, the reciprocal transfer of farmland, forestland, and grassland was visible, and the shift was considerable due to the GGP and the Natural Forest Protection Project. Water areas, barren land, and built-up land converted to farmland also increased, indicating that Shaanxi Province has developed some other types of land to make up for the decrease in farmland caused by the project's implementation. The increase in conversion to built-up land in all regions indicates economic development and accelerated urbanization.

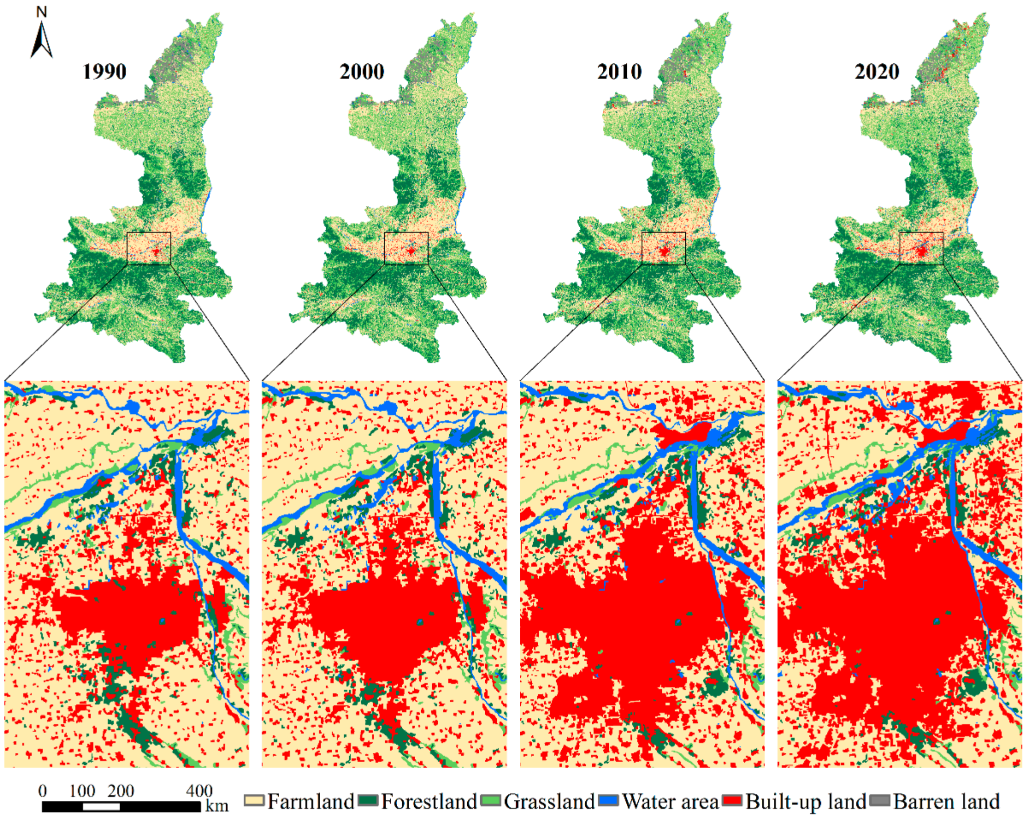

Figure 3. Spatial distribution of land-use in Shaanxi Province from 1990 to 2020.

Table 3. Land-use transfer matrix of Shaanxi Province from 1990 to 2000.

1990	2000					
	Farmland	**Forestland**	**Grassland**	**Water Areas**	**Built-Up Land**	**Barren Land**
Farmland	7,122,855.87	5980.59	55,325.07	8615.43	42.48	3296.16
Forestland	11,240.01	4,592,455.74	25,334.28	108.36	2.07	6763.77
Grassland	5923.44	15,703.47	7,623,471.69	3338.91	7.11	129,499.57
Water areas	3624.03	156.24	2483.64	174,302.19	0.36	841.41
Built-up land	35,707.32	1859.94	852.21	28.35	276,464.70	298.26
Barren land	3543.75	231.84	8134.66	293.04	0.27	474,849.45

3.2. ESV Analysis

3.2.1. Time Variation Analysis of the ESV

The total ESV in Shaanxi Province increased initially and then decreased during the research period (Table 5). The total value rose from USD 3802.82 billion in 1990 to USD 3814.90 billion in 2000, rose further to USD 3836.20 billion in 2010, and then declined to USD 3806.50 billion in 2020. Before the implementation of the project, the total ESV in Shaanxi Province increased by 0.32%; the growth rate slowed after the implementation of the project, with a growth rate of 0.10% throughout the study period. The main reason for this is that the built-up area increased, and the ESV provided by built-up land is negative. Grassland had the highest ESV, followed by forestland and farmland. The ESV of farmland reached its maximum level in 2000, and the ESV given after the project's implementation continued to decline. The forestland ESV grew over the analyzed period. Although the ESV provided by grassland decreased in the later period, it also exhibits an increasing trend in general. The ESVs of water areas, built-up land, and barren land all fell in varying degrees, owing mainly to the continuous reductions of water areas and barren land. Although the total area of built-up land increased, the ESV provided by built-up land is negative, so the value decreased, and the change was most apparent.

Table 4. Land-use transfer matrix of Shaanxi Province from 2000 to 2020.

2000	2020					
	Farmland	**Forestland**	**Grassland**	**Water Areas**	**Built-Up Land**	**Barren Land**
Farmland	6,401,275.11	32,459.40	197,398.08	8153.10	12,473.91	14,915.97
Forestland	152,720.37	4,495,579.20	180,160.65	793.71	2379.33	1240.74
Grassland	441,281.97	71,274.15	7,299,567.00	4270.68	1729.17	17,701.57
Water areas	18,791.28	1273.68	6219.27	150,438.78	614.88	1443.24
Built-up land	158,224.86	7000.92	45,515.07	1613.25	297,252.81	18,149.13
Barren land	3875.04	4972.95	16,767.36	484.57	15.39	421,799.85

Table 5. Changes in the ESV of different land-use types in Shaanxi Province from 1990 to 2020.

Land-Use Type	ESV ($\times 10^8$ USD)				Change Rates (%)			
	1990	**2000**	**2010**	**2020**	**1990–2000**	**2000–2010**	**2010–2020**	**1990–2020**
Farmland	461.81	462.66	438.90	428.63	0.18 ↑	−5.13 ↓	−2.34 ↓	−7.18 ↓
Forestland	1480.06	1486.32	1540.04	1549.53	0.42 ↑	3.61 ↑	0.62 ↑	4.69 ↑
Grassland	1514.97	1527.21	1549.10	1538.62	0.81 ↑	1.43 ↑	−0.68 ↓	1.56 ↑
Water areas	381.68	381.68	368.96	365.56	0	−3.33 ↓	−0.92 ↓	−4.22 ↓
Built-up land	−42.22	−48.12	−65.70	−80.58	−13.99 ↓	−36.52 ↓	−22.64 ↓	−90.86 ↓
Barren land	6.51	5.15	4.90	4.74	−20.88 ↓	−4.84 ↓	−0.34 ↓	−27.23 ↓
Total	3802.82	3814.90	3836.20	3806.50	0.32 ↑	0.56 ↑	−0.77 ↓	0.10 ↑

Based on the changes in ESV in Shaanxi Province from 1990 to 2020 (Table 6), the proportion of each single ESV was relatively stable, in the following order: hydrological regulation > climate regulation > climate regulation > gas regulation > biodiversity maintenance > environment purification > environment purification > aesthetic landscape > raw materials > nutrient-cycle maintenance > water supply. Before the implementation of the GGP, aside from the decreasing trends in water supply services and environmental purification services, all kinds of services exhibited increasing trends. Food production, hydrological regulation, and nutrient-cycle maintenance services showed a decreasing trend to different degrees after project implementation. After the implementation of the project, the ESV showed varying degrees and different directions. Over the whole research period, the ESV increased for raw materials, gas regulation, climate regulation, soil conservation, biodiversity maintenances, and aesthetic landscape, among which aesthetic landscape showed the greatest increase. ESV decreases were observed for food production, water supply, environmental purification, hydrological regulation, and nutrient-cycle maintenance, among which the greatest decrease was for water supply.

Table 6. Changes in different ESVs in Shaanxi Province from 1990 to 2020.

Ecosystem Service Type	ESV (×10⁸ USD)				Changes Rates (%)			
	1990	2000	2010	2020	1990–2000	2000–2010	2010–2020	1990–2020
Food production	181.21	181.93	176.84	174.30	0.40 ↑	−2.80 ↓	−1.43 ↓	−3.81 ↓
Raw materials	117.54	118.28	119.55	119.36	0.63 ↑	1.07 ↑	−0.16 ↓	1.55 ↑
Water supply	−97.58	−99.93	−98.71	−101.45	−2.41 ↓	1.22 ↑	−2.77 ↓	−3.97 ↓
Gas regulation	401.91	403.80	405.73	403.25	0.47 ↑	0.48 ↑	−0.61 ↓	0.33 ↑
Climate regulation	891.30	896.34	914.65	91,334	0.57 ↑	2.04 ↑	−0.14 ↓	2.47 ↑
Environment purification	281.58	281.23	281.64	277.08	−0.12 ↓	0.15 ↑	−1.62 ↓	−1.60 ↓
Hydrological regulation	1036.67	1036.93	1021.94	1006.54	0.03 ↑	−1.45 ↓	−1.51 ↓	−2.91 ↓
Soil conservation	423.58	425.78	431.57	430.05	0.52 ↑	1.36 ↑	−0.35 ↓	1.53 ↑
Nutrient-cycle maintenance	45.95	46.15	45.90	45.48	0.43 ↑	−0.55 ↓	−0.91 ↓	−1.04 ↓
Biodiversity maintenance	356.64	358.77	366.30	366.16	0.60 ↑	2.10 ↑	−0.04 ↓	2.67 ↑
Aesthetic landscape	164.00	165.60	170.80	172.38	0.98 ↑	3.14 ↑	0.93 ↑	5.11 ↑
Total	3802.82	3814.90	3836.20	3806.50	0.32 ↑	0.56 ↑	−0.77 ↓	0.10 ↑

3.2.2. Spatial Variation Analysis of ESV

In order to analyze the spatial and temporal variation characteristics of the ESV more accurately, based on relevant research [47], we used a 5 km × 5 km grid as the primary research unit to reveal the spatial evolution pattern of the ESV in Shaanxi Province. The grid maps of ESV in Shaanxi Province in 1990, 2000, 2010, and 2020 were calculated using ArcGIS 10.8 software. The ESV in the four periods was then separated into five classes using the Natural Jenks method: low, lower, medium, higher, and high. Finally, for 1990, 2000, 2010, and 2020, spatial distribution maps of ESV in Shaanxi Province were obtained (Figure 4).

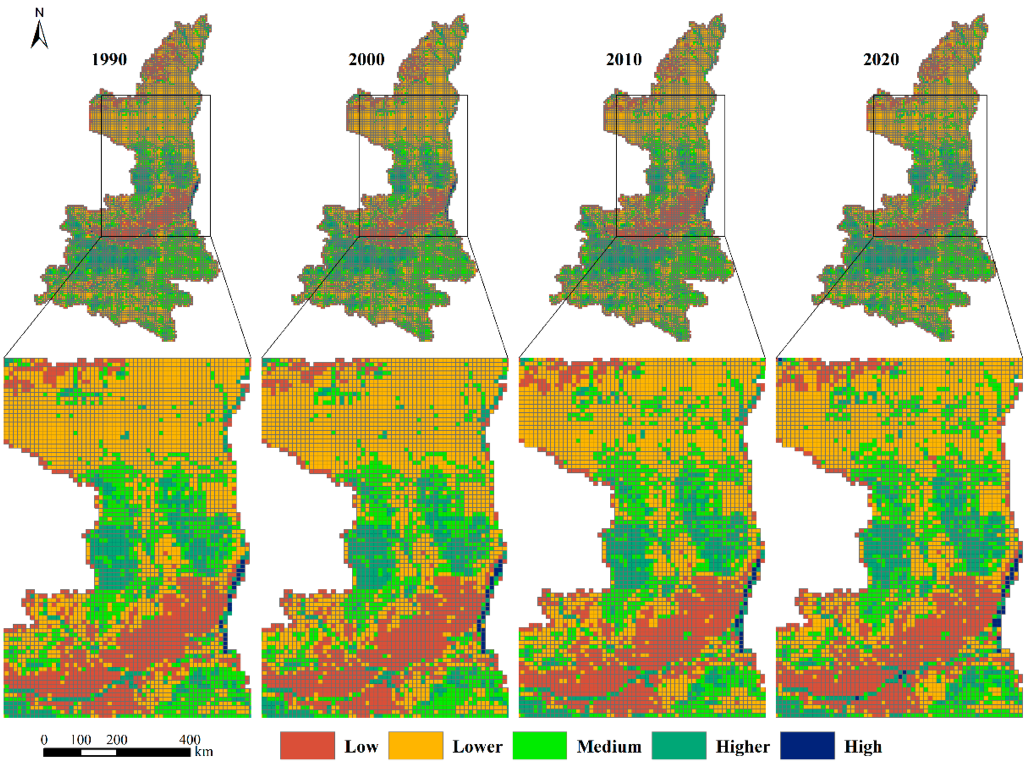

Figure 4. Spatial distribution patterns of ESVs in Shaanxi Province from 1990 to 2020.

The general regional distribution patterns of high in the south, low in the north, and lowest in the middle can be seen in Figure 4, indicating that the spatial distribution pattern of ESV in Shaanxi Province is largely constant. The southern and central regions of the area have more-favorable external environments for plant development due to the elevation and latitude differences in the regions. Grassland and forestland are the most common terrain types in high-value locations, contributing to an increased ESV. The central urban area and the northern part of Shaanxi Province have the highest concentrations of low ESV regions because the central region's urbanization is growing, and the proportion of built-up land is gradually increasing; however, the ESV of built-up land is negative, resulting in a low ESV in the corresponding range. In the northern, low ESV area, the sandy and desert land-use categories predominate, and the ESV is low. The high-level areas of ESV in Shaanxi Province were essentially consistent in terms of spatial evolution from 1990 to 2020. The regions with high and medium ESVs exhibited a tendency toward expansion. At the same time, the areas with low and lower ESVs showed diminishing trends, and the changes were mainly concentrated in the period of time after the project was implemented.

4. Discussion

4.1. Effects of the GGP on Land-Use Change

The GGP is China's most comprehensive ecological restoration project, with the most vital policy, the most investment, and the best results. The implementation of the project has brought about quantifiable changes in surface cover, especially regarding the three land-use types of cultivated land, forestland, and grassland, and it has had an observable impact on the structure and service functions of China's ecosystems [48,49]. The GGP has led to reductions in cultivated land and has accelerated the increase in forest cover (Table 7). In contrast, the changes in grassland are minor. Affected by the GGP, the dynamic degree of farmland, forestland, and grassland changed from 0.02%, 0.04%, and 0.08% before the implementation of the project to −0.37%, 0.21%, and 0.04% after the implementation of the project, respectively. The implementation of the project has achieved remarkable results that have improved the coverage rate of forest vegetation and the ecological environment.

Table 7. Dynamic degree of cultivated land, forestland, and grassland in Shaanxi Province from 1990 to 2020 (in %).

Year	Farmland	Forestland	Grassland
1990–2000	0.02	0.04	0.08
2000–2020	−0.37	0.21	0.04

4.2. Effects of the GGP on the ESV

Land-use change has a quantifiable impact on the ESV. The implementation of the GGP effectively changed the ESV of farmland, forestland, and grassland in the region [5,40]. Table 8 shows that, as the project was implemented, the area of farmland was gradually reduced, the ESV was considerably lowered, and it shifted from 0.18% before project implementation to 7.36% after project implementation. The ESV rose dramatically as the forestland area increased, and the dynamic degree changed from 0.42% before project implementation to 4.25% after project implementation. The ESV of grassland changed little, both before and after the implementation of the project. The main reason for this was more mutual transformation between grassland and other land uses, and the overall change was small.

Table 8. Dynamic degree of the ESVs of cultivated land, forestland, and grassland in Shaanxi Province from 1990 to 2020 (in %).

Year	Farmland	Forestland	Grassland
1990–2000	0.18	0.42	0.81
2000–2020	−7.36	4.25	0.75

Combining Tables 5 and 8, the implementation of the GGP had an observed impact on the change in the ESV in Shaanxi Province. Although the total value of Shaanxi Province changed little during the study period, the ESVs of farmland and grassland were effectively improved. With the implementation of the project and the accelerating process of urbanization and industrialization in China, a part of the farmland has been consumed and occupied, and the area of built-up land has increased, resulting in a decrease in the regional ESV. Therefore, to ensure the benefits of project implementation, basic farmland should be protected in the future so as to safeguard the amount of farmland while avoiding the expansion of built-up land.

4.3. Selection of Evaluation Methods

ESV is a prevalent issue, and many different assessment methods have been created, making it a valuable tool for land-use planning and evaluation [50,51]. Different ESV evaluation models have different parametric needs. Different factors, such as market price, value coefficient, and land-use data, will affect the ESV and its accuracy [52,53]. Considering the above facts, in our research, we chose the equivalent factor method based on Costanza and Xie et al. [3,20], which is widely used in China. The equivalent factor method evaluates the ecosystem service function value of the major crops in the study region based on land-use data, requiring fewer data and a shorter evaluation time. Although the equivalent factor method cannot account for spatial heterogeneity, and coefficient selection is subjective, we can alter the coefficient depending on the current circumstances in the research region to improve the accuracy of the results to some extent [54,55]. The correction of the coefficient is affected by factors such as grain prices and the GDP in different years in the region. The average value of grain prices in the study period was used in this paper, and a more reasonable and accurate method is an aspect which could benefit from further improvement.

The province of Shaanxi is in northern and western China. The vegetation varieties in northern and southern Shaanxi, which are influenced by geography and climate, are significantly varied, as are the land-use patterns. Most existing research [27,37,56] has focused on determining the ESV in northern Shaanxi, but in this work, we used the same index method across the entire province of Shaanxi. The evaluation process is characterized by certain inaccuracies, which is a concern that should be addressed in the future. The ecological environment is a complex, diverse, and ambiguous system. The evaluation method for ESV is neither scientific nor complete, and the results are questionable. More scientific and perfect evaluation systems should be investigated in the future.

4.4. Prospects

Forest ecosystems are the main body of terrestrial ecosystems and can provide various ESs, such as water conservation, soil conservation, and biodiversity protection [57]. Many countries worldwide are aware of the importance of forest ecosystems and have adopted a range of policy measures to enhance ESV. For example, the National Forest Strategy, Biodiversity Strategy, and Bioeconomy Strategy have been implemented by Finland [58]. ESs are mentioned in forest-related policies in Bangladesh, but none provide details on the ESV, the decision-making process, or the scale of implementation [59]. In developing countries, the assessment of the concept of adopting related forest policies to support forest management is not yet fully understood, so the GGP in China and similar engineering measures implemented in other countries can provide theoretical lessons for countries that have not implemented such measures.

In Shaanxi Province, the government-led GGP plays a key role in environmental restoration and conservation. The development and utilization of various land-use types should be adapted to local conditions when developing future land-use plans. Land-use change affects the regional ESV, but so can topography, climate, population density, economic level, urbanization level, and a variety of other natural and socio-economic variables. This paper only discusses the spatial and temporal evolution of the ESV from the dynamic and transfer of land-use types. In the future, when conducting relevant research, we can focus on the spatial and temporal changes in the regional ESV that are driven by natural factors and socio-economic factors, along with conducting simulation and prediction research to improve the accuracy of the evaluation results. It is still necessary to further explore the influencing factors of ESV changes in future research. In addition, the tradeoff and synergy of ESs, supply and demand, and spatial transfer are future issues to be explored.

5. Conclusions

In this study, the land-use change and the spatial and temporal evolution pattern of the ESV before and after the implementation of the GGP in Shaanxi Province were evaluated using land-use data from Shaanxi Province from 1990, 2000, 2010, and 2020. The following are the primary conclusions:

Farmland, forestland, and grassland are the three primary land-use types in Shaanxi Province. Between 1990 and 2000, the three land-use types—farmland, forestland, and grassland—underwent massive changes in Shaanxi Province due to the GGP. The area of farmland decreased, with most of it being converted to forestland or grassland, while the areas of forestland and grassland gradually rose.

The ESV in Shaanxi Province was USD 3802.82 billion in 1990, USD 3814.90 billion in 2000, USD 3836.20 billion in 2010, and USD 3806.50 billion in 2020, with a pattern of initial growth followed by decreases. The value provided by hydrological regulation is the highest among the ESVs, whereas the value provided by water supply is the lowest. The high-value areas are mainly distributed in the south, and the land-types are mainly forestland and grassland. The low-value areas are mainly distributed in the middle, and the land-type is mainly built-up land.

The GGP has enhanced the ESVs of forestland and grassland, but the continual development of built-up land has limited the extent of other land-types, resulting in a decrease in the total ESV of Shaanxi Province. In the future, existing policies should be appropriately adjusted, forestland and grassland preservation should be enhanced, and essential farmland development should be strengthened. Polices should improve the efficiency of land use, rationalize the planning of urban and rural built-up land, and enhance the region's sustainable development.

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