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Research Article

Analysis of Land Use Changes and Driving Forces in the Yanhe River Basin from 1980 to 2015

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Based on the support of RS and GIS technology, this paper analyzes the spatial and temporal variation characteristics and driving forces of land use in the Yanhe River Basin through the processing and interpretation of remote sensing images in different periods from 1980 to 2015 and the methods of the land use transfer matrix and dynamic attitude. The results show that cropland, grassland, and forest land are the three types of land use with the most obvious changes, while urban land and water body have relatively small changes in the Yanhe River Basin. The transfer between cropland, forest land, and grassland and urban land is very obvious, among which the conversion rate of cropland is the highest. During the 15 years from 2000 to 2015, the land use types of the Yanhe River Basin changed by 13.17%, with an average annual growth rate of 0.88%. The implementation of ecological restoration and governance policy is the direct driving force of land use change in the Yanhe River Basin. The results obtained in this study can provide reference basis for land use planning and management and land use structure optimization in the Yanhe River Basin in the future.

1. Introduction

Land use change is an important manifestation of human activities on terrestrial surface ecosystems [1]. It mainly changes the nature of the surface through the joint action of climate change and human activities. Land use patterns are constantly changing with the rapid development of human society, so the change of land use is also an important way to reflect the impact of human activities on the natural environment [2]. Since the 21st century, lots of studies show that land use change has caused natural disasters, energy shortage, food shortage, economic crisis, and other social and ecological problems [3]. Therefore, the international geosphere biosphere program (IGBP) and the humanity factor in global environmental change program (IHDP) proposed the research on the rules of land use change and driving force analysis as the core research direction in order to reduce the negative impact of land use change on natural and social [4]. This is of great significance to the sustainable development of the society [5]. At present, human researches on land use change mainly focus on the speed of land use type change, direction of land use type transfer, degree of land use, and driving factors [6, 7]. In terms of research methods, scholars usually use mathematical statistics and establish the corresponding mathematical model by remote sensing images [8]. Many scholars in China have studied land use change in different scales by using different indicators. For the study of large-scale areas, Liu et al. [9, 10] analyzed the spatial and temporal change characteristics of large-scale regional land use in China in the early 21st century by using the indicators of comprehensive land use dynamic attitude and land use degree change and revealed the spatial pattern and major driving factors of land use change in China through the dynamic land use zoning map. And they analyzed the temporal and spatial pattern and new characteristics of land use change in China from 2010 to 2015 by comparing with the temporal and spatial pattern of land use change in the early 21st century. For the study of small and medium scale areas, Liao et al. [11] analyzed the rate of change of land use in the Yellow River Basin based on the land use data in the six phases from 1980 to 2015 and analyzed the transfer types and quantities of land use in the whole basin and provinces within the basin from 1980 to 2000 and from 2000 to 2015 by using the land use transfer matrix, and finally pointed out that the most important factors driving the land use change in the Yellow River Basin were climate change, population increase, and economic development.

The Yanhe River Basin is a large tributary of the middle reaches of the Yellow River and also a key basin of sediment source of the Yellow River [12]. As a typical representative of hilly and gully region on the Loess Plateau, it has suffered serious soil erosion for a long time. Due to the overexploitation and utilization of land resources by human being and some nature factors, the ecological system in this region is very fragile and highly sensitive to external disturbance [13]. With the rapid development of social economy, especially after the implementation of the ecological policy of "returning farmland to forest" in China at the end of 1999, great changes have taken place in the land use structure of Yan River Basin and remarkable achievements have been made in soil and water conservation measures [14]. At present, abundant achievements have been made in the study of land use change in the Yanhe River Basin. For example, Li et al. [15] discussed the impact of land use change in the Yanhe River Basin on the ecological service value of the basin. Ran et al. [16] analyzed the scale conversion method of land use/cover change model in the Yanhe River Basin. Li et al. [17] analyzed the impact of soil and water conservation measures on runoff and sediment in the Yanhe River Basin. Wei et al. [18] and Xie et al. [19], respectively, revealed the impact of the policy of " returning farmland to forest" on the temporal and spatial change of land use and soil erosion in the Yanhe River Basin. However, there are relatively few researches on the land use change in the Yanhe River Basin in the longer time series. This study analyzed the temporal and spatial variation characteristics of land use in the Yanhe River Basin from 1980 to 2015 and analyzed the driving factors of land use change in the Yanhe River Basin in the past 35 years on this basis, so as to grasp the overall trend of land use change in the Yanhe River Basin in the past 35 years correctly and provide reference basis for land use planning and management and land use structure optimization in the Yanhe River Basin.

2. Data and Methods

2.1. Study Area. The Yanhe River Basin is located in the central loess Plateau in northern Shaanxi Province, the geographic coordinates are $36^{\circ}21'$-$37^{\circ}19'$N and $108^{\circ}38'$-$110^{\circ}29'$E (Figure 1). The basin covers a total area of 7,725 square kilometers, with a total length of 286.9 km, and is the second largest river in northern Shaanxi. The basin belongs to the continental semiarid climate of warm temperate zone, with annual rainfall of about 510 mm and average annual temperature of 9°C. The topographic conditions in the basin are complex, mainly loess hilly gully topography; soil and water loss is very serious. Natural disasters also occur frequently in the river basin, mainly including heavy rains, sandstorms, droughts, and frosts.

2.2. Data. In this study, seven stages of multispectral remote sensing images are selected for the Yanhe River Basin in 1980, 1990, 1995, 2000, 2005, 2010, and 2015. They are all from the geospatial data cloud (http://www.gscloud.cn), including Landsat3 (MSS), Landsat5 (TM), Landsat7 (ETM+), and Landsat8 (OLI). The operability of remote sensing images and the clarity of ground features should be taken into account when the classification system of land use change is established. According to the national general land use classification system and the actual situation of the Yanhe River Basin, combined with the related research of previous scholars, considering the weak changes of bare land and the possible influence on the accuracy of the supervised classification of remote sensing images, five main land use types, including cropland, forest land, grassland, urban land, and water area, were selected (Table 1).

Taking 2015 Landsat8 image pretreated as an example, band 5, band 4, and band 3 were selected for synthesis. Firstly, radiation calibration, atmospheric correction, and geometric correction were carried out for the images by ENVI processing tool. But the area of Yanhe River Basin is very large; three overlapped remote sensing images of each other need to be downloaded to cover it completely at least. And the vector boundary of the basin was used for clipping; the three images were joined by the seamless mosaic tool. Finally, visual interpretation was performed by combining topographic map, Google Earth and other tools with the SVM supervised classification method. According to the confusion matrix table, the overall classification accuracy is 95.87% and the kappa coefficient is 0.92, indicating good interpretation accuracy (Figure 2). At last, we obtained land use types maps of the Yanhe River Basin in seven stages (Figure 3).

2.3. Analysis Methods

2.3.1. Land Use Transfer Matrix. Land use transfer matrix is the application of the Markov model in land use change. The Markov model can not only quantitatively show the conversion between different land use types but also reveal the transfer rate between different land use types. Transfer matrix is the main method to conduct quantitative research on the quantity and direction characteristics of the mutual transformation between land use types, which can specifically reflect the structural characteristics of land use change and the direction of transfer among different

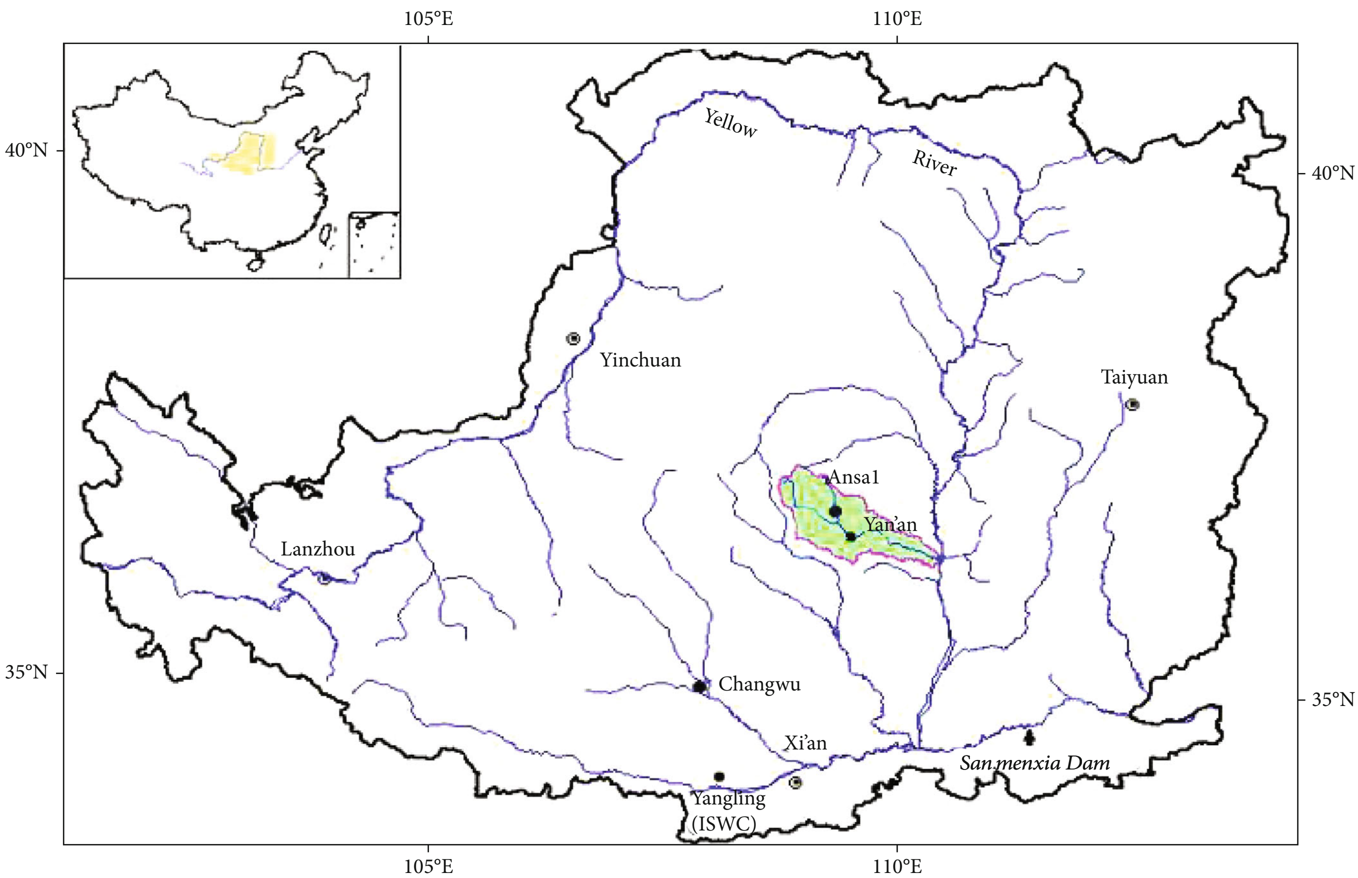


Figure 1: Location of the study area.

Table 1: Land use types.

Land use types	Meaning
Cropland	Refers to land planted with crops, including cultivated land, newly developed land, land for consolidation, and land for leisure
Forest land	Refers to the land where trees, bamboos, and shrubs grow and the land along the coast where mangroves grow
Grassland	Refers to the growth of herbaceous plants which is given priority to land
Water body	Refers to land water, ditches, hydraulic structures, and other land
Urban land	Refers to land used for industrial, mining, transportation, and other purposes outside counties and towns as well as other land used for construction purposes

types [20]. Its mathematical expression is as follows:

$$S_{ij} = \left\{ \begin{array}{ccccc} S_{11} & S_{12} & S_{13} \cdots & & S_{1n} \\ S_{21} & S_{22} & S_{23} & \cdots & S_{2n} \\ S_{31} & S_{32} & S_{33} & \cdots & S_{3n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ S_{n1} & S_{n2} & S_{n3} & \cdots & S_{nn} \end{array} \right\}, \quad (1)$$

where S is the variation area of each land use type, n is total types of land use, and i and j are the types of land use at the beginning and end of the study.

2.3.2. Land Use Dynamic Attitude

(1) Single land use type dynamic attitude: it refers to the quantitative change of a certain land use type within a certain research area within a certain period [21], which is usually expressed by percentage, and its expression is as follows:

$$K_T = \frac{U_b - U_a}{U_a} \times 100\%, \quad (2)$$

where K_T is the dynamic attitude of a certain type of land use in the research area and U_a and U_b are the

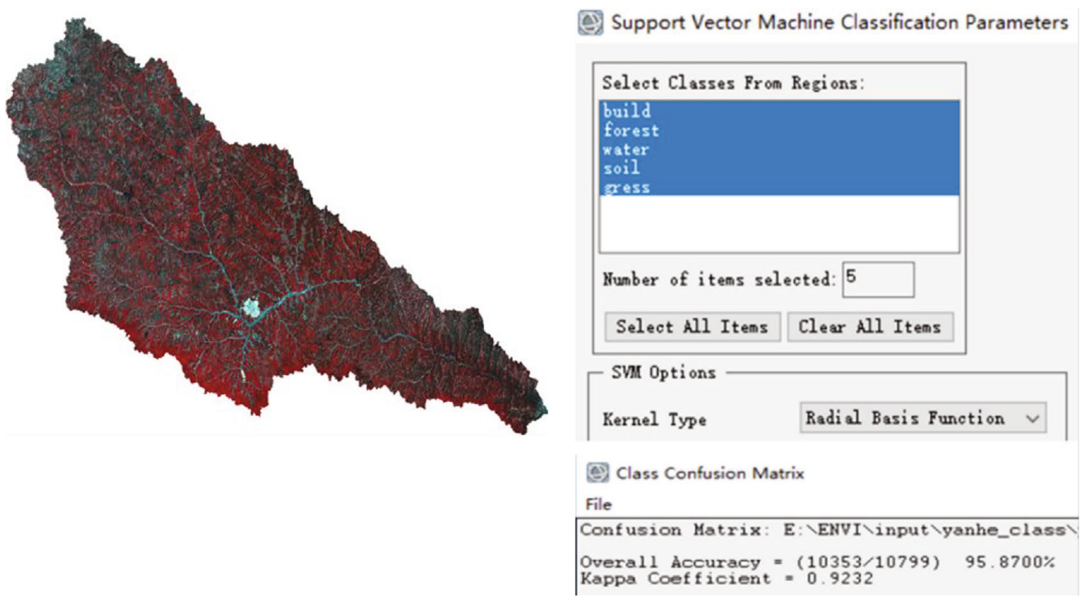


Figure 2: Processing and classification precision of remote sensing image in 2015.

areas of a certain type of land use at the beginning and end of the study.

(2) Comprehensive land use dynamic attitude: it reflects the total land activity attitude in the study area and refers to the percentage of the total area of each land use type changed in the study area [22]. Its expression is follows:

$$LC_T = \left(\frac{\sum_{i=1}^{n} \Delta LU_{ij}}{\sum_{i=1}^{n} LU_i} \right) \times 100\%, \qquad (3)$$

where LC_T is comprehensive land use dynamic attitude, ΔLU_{ij} is the area of i land use types converted to non-$j(j = 1 \cdots n)$ land types during the study period, LU_i is the area of type I land use at the beginning of the study, and n is total types of land use.

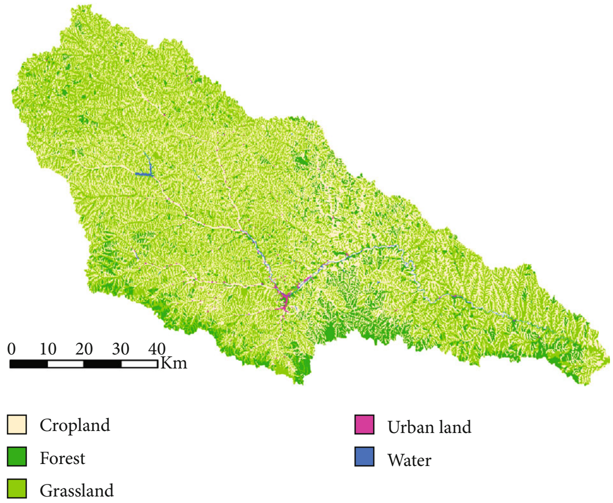
3. Results and Analysis

3.1. General Characteristics of Land Use Change. According to the seven stages land use type maps, based on the initial implementation of the policy of returning farmland to forest (grass) in 2000, the land use change maps of the Yanhe River Basin from 1980 to 2000 and from 2000 to 2015 (Figures 4 and 5) and total land use change area of the Yanhe River Basin (Table 2) are obtained using Arcgis10.2, respectively.

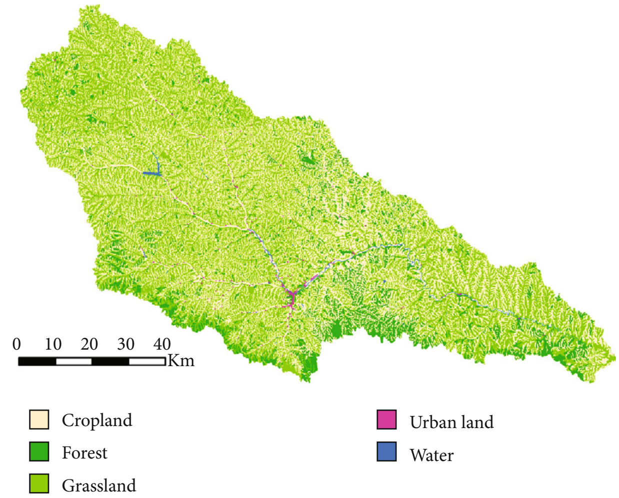
Table 2 shows that the overall change range of land use types in the Yanhe River Basin was very small from 1980 to 2000. Forest land and grassland were the land types with the biggest change in area, and cropland, water body, and urban land had little change in area. The types of land use with increased area were forest land and urban land, respectively, and the types with decreased area were grassland, cropland, and water body. The area of forest land increased from 826.78 km^2 in 1980 to 857.77 km^2 in 2000, with an increase of 30.99 km^2, meanwhile the overall proportion of the Yanhe River Basin increased from 10.82% to 11.22%, with the largest increase of 0.4%. The area of grassland decreased from 3,473.14 km^2 in 1980 to 3,443.63 km^2 in 2000, with a decrease of 29.51 km^2. The overall proportion of the Yanhe River Basin decreased from 45.45% to 45.06%, with the largest decrease of 0.39%.

And from 2000 to 2015, cropland was the land with the largest area change, followed by the forest land and grassland, the water body with the smallest in the Yanhe River Basin. The types of land use with increased area were forest land, grassland, and urban land, and the types with decreased area were cropland and water body, respectively. The area of cropland decreased by 863.18km^2 from 3,289.13 km^2 in 2000 to 2,425.95 km^2 in 2015. The overall proportion of the Yanhe River Basin decreased from 43.04% to 31.74%, and the area decreased by 11.3%, with the largest reduction. The area of grassland increased from 3,443.63 km^2 in 2000 to 4,016.95 km^2 in 2015, with an increase of 573.32 km^2. The overall proportion of the Yanhe River Basin increased from 45.06% to 52.56%, and the area increased by 7.5%, with the largest increase. The area of forest land increased from 857.77 km^2 in 2000 to 1,127.50 km^2 in 2015, with an increase of 269.73 km^2. The overall proportion of the Yanhe River Basin increased from 11.22% to 14.75%, and the area increased by 3.53%, with an obvious increase. The area of urban land increased from 26.73 km^2 in 2000 to 46.93 km^2 in 2015, with an increase of 20.2 km^2. The overall proportion of the Yanhe River Basin increased from 0.35% to 0.61%, and the area increased by 0.26%, with an obvious increase.

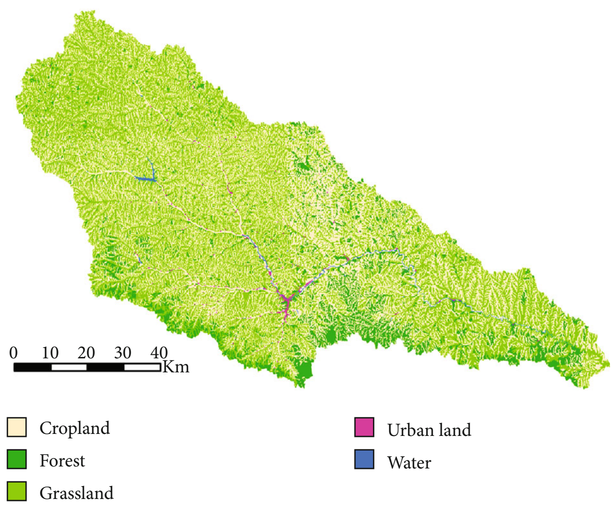
3.2. Land Use Change Transfer Matrixes from 1980 to 2015. In order to explore the internal structure and characteristics of land use types in the Yanhe River Basin, four land use transfer matrixes are generated by superposition analysis of Arcgis10.2 (Table 3–6), so as to analyze the inflow and



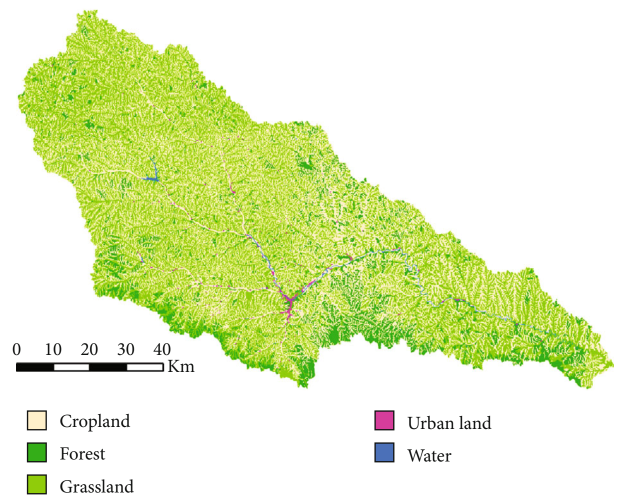
(a) Land use types of the Yanhe River Basin in 1980



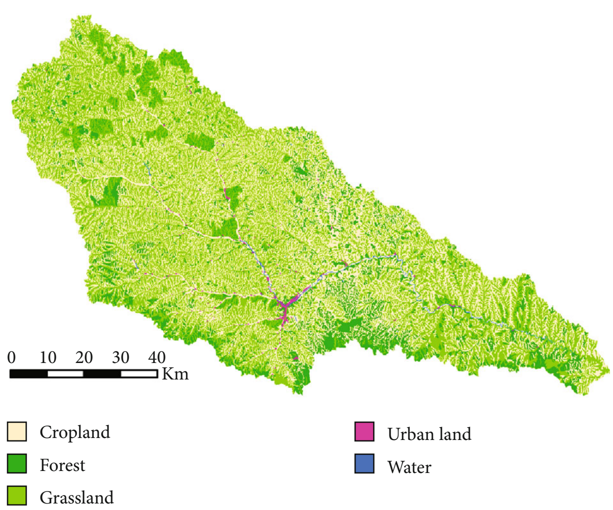
(b) Land use types of the Yanhe River Basin in 1990



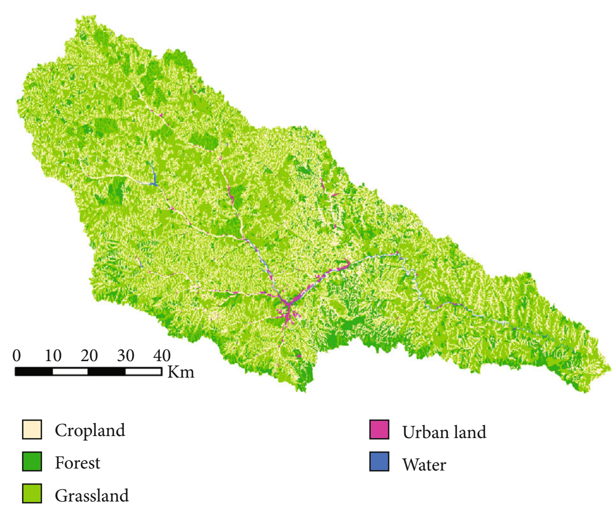
(c) Land use types of the Yanhe River Basin in 1995



(d) Land use types of the Yanhe River Basin in 2000

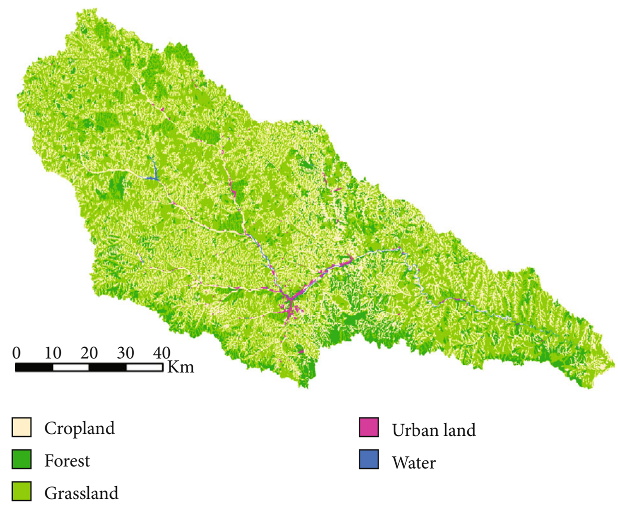


(e) Land use types of the Yanhe River Basin in 2005



(f) Land use types of the Yanhe River Basin in 2010

Figure 3: Continued.



(g) Land use types of the Yanhe River Basin in 2015

Figure 3: Land use types in the Yanhe River Basin from 1980 to 2015.

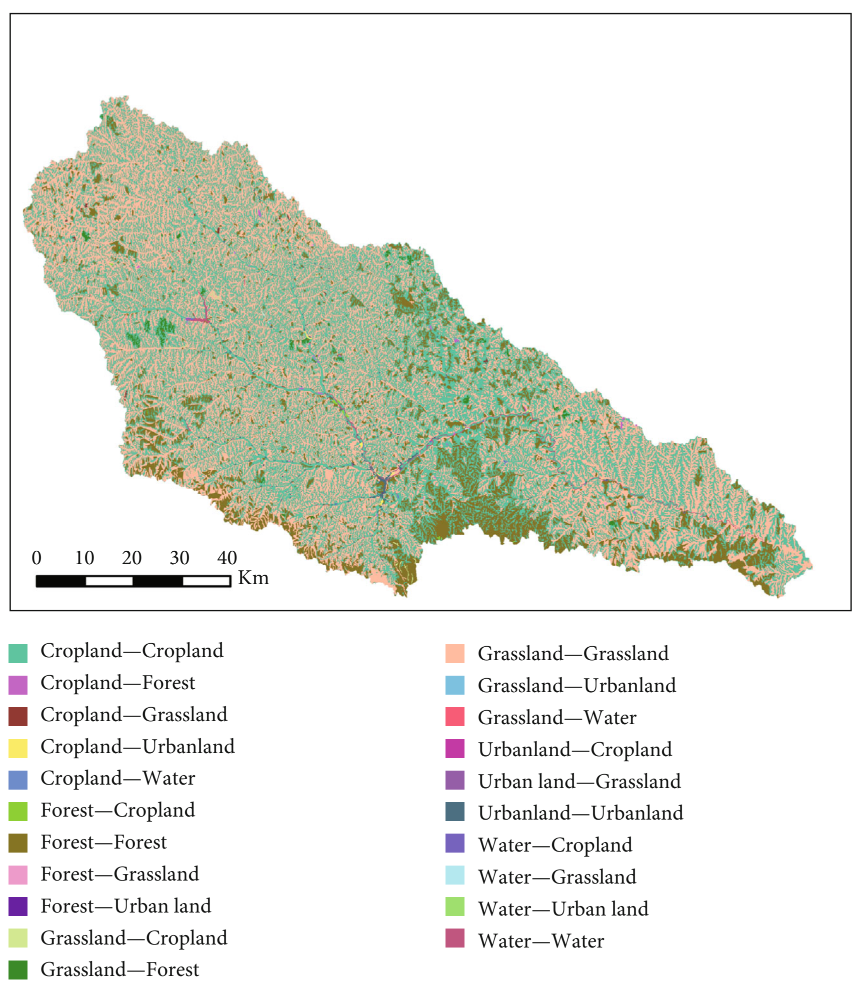


Figure 4: Land use changes of the Yanhe River Basin from 1980 to 2000.

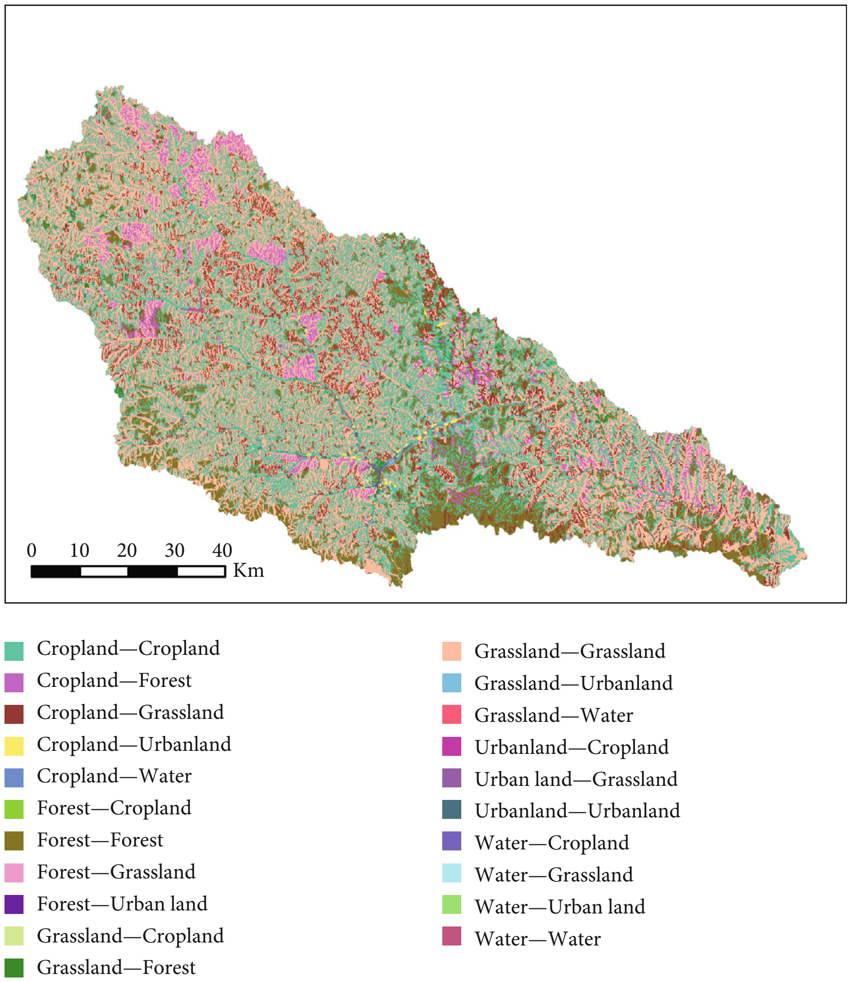


Figure 5: Land use changes of the Yanhe River Basin from 2000 to 2015.

Table 2: Statistics for land use changes of the Yanhe River Basin from 1980 to 2015 (km^2, %).

Land use type	1980		2000		2015	
	Area	Ratio	Area	Ratio	Area	Ratio
Cropland	3292.12	43.08	3289.13	43.04	2425.95	31.74
Forest	826.78	10.82	857.77	11.22	1127.50	14.75
Grassland	3473.14	45.45	3443.63	45.06	4016.95	52.56
Water	27.15	0.36	25.08	0.33	25.01	0.33
Urban land	23.16	0.30	26.73	0.35	46.93	0.61
Total	7642.35		7642.34		7642.34	

outflow of different land use types in the Yanhe River Basin from 1980 to 2015.

From Table 3, for the three major land use types from 1980 to 1990, the conversion area of grassland was 144.94 km^2, and the conversion rate was 4.17%, among which 3.94% was converted into cropland and 0.2% into forest land. The conversion area of cropland was 158 km^2, and the conversion rate was 4.8%, among which 4.17% was converted to grassland and 0.58% to forest land. The conversion area of forest land was 28.33 km^2, and the conversion rate was 3.42%, among which 0.9% was converted to grassland and 2.5% to cropland. During this period, all land use types in the Yanhe River Basin did not change significantly.

The transition matrix of land use change in Table 4 explains some changes in the Yanhe River Basin from 1990 to 2000 in detail. The conversion area of grassland was 175.65 km^2, and the conversion rate was 5.33%, among which 4.21% was converted into cropland and 1.07% into forest land. The conversion area of cropland was165.35 km^2, and the conversion rate was 5.29%, among which 4.35% was converted to grassland and 0.81% to forest land. The conversion area of forest land was 27.57 km^2, and the conversion rate was 3.46%, among which 2.48% was converted to cropland and 0.92% to grassland. The result showed that all land use types in the Yanhe River Basin changed little during this period. During this period, the land use types of the Yanhe River Basin mainly changed from grassland to forest land. It was related to the implementation of various soil and water conservation measures in the Yanhe River Basin at the end of the 20th century, which indicated that the comprehensive management of fragile ecological environment had achieved certain results.

From Table 5, the conversion area of grassland was 88.47 km^2, and the conversion rate was 2.64%, among which 1.47% was converted into cropland and 1.01% into forest

Table 3: The transition matrix of land use change of the Yanhe River Basin from 1980 to 1990 (km^2).

		1980 Grassland	Urban land	Cropland	Forest	Water	Total
1990	Grassland	3328.18	0.48	137.21	7.45	0.80	3474.12
	Urban land	0.41	21.95	0.70	0.08	0.05	23.18
	Cropland	136.84	0.60	3134.09	20.67	1.08	3293.28
	Forest	6.96	0.08	19.17	798.40	0.13	824.73
	Water	0.73	0.06	0.92	0.13	25.09	26.93
	Total	3473.12	23.16	3292.09	826.73	27.15	7642.24

Table 4: The transition matrix of land use change of the Yanhe River Basin from 1990 to 2000 (km^2).

		1990 Grassland	Urban land	Cropland	Forest	Water	Total
2000	Grassland	3298.48	0.40	136.01	7.34	1.38	3443.61
	Urban land	0.68	22.22	3.42	0.34	0.07	26.73
	Cropland	138.86	0.45	3127.93	19.75	2.12	3289.10
	Forest	35.22	0.07	25.13	797.17	0.13	857.72
	Water	0.89	0.05	0.79	0.13	23.22	25.08
	Total	3474.12	23.18	3293.28	824.73	26.93	7642.24

Table 5: The transition matrix of land use change of the Yanhe River Basin from 2000 to 2010 (km^2).

		2000 Grassland	Urban land	Cropland	Forest	Water	Total
2010	Grassland	3355.16	0.32	654.53	4.22	0.60	4014.83
	Urban land	4.61	25.92	15.45	0.80	0.11	46.89
	Cropland	49.12	0.43	2368.02	8.71	1.91	2428.19
	Forest	33.84	0.03	250.34	843.96	0.16	1128.33
	Water	0.90	0.03	0.80	0.08	22.29	24.10
	Total	3443.63	26.73	3289.13	857.77	25.08	7642.34

Table 6: The transition matrix of land use change of the Yanhe River Basin from 2010 to 2015 (km^2).

		2010 Grassland	Urban land	Cropland	Forest	Water	Total
2015	Grassland	3977.69	0.21	31.48	7.41	0.17	4016.95
	Urban land	0.22	46.33	0.26	0.07	0.05	46.93
	Cropland	30.14	0.27	2390.31	5.09	0.14	2425.95
	Forest	6.52	0.06	5.19	1115.70	0.03	1127.50
	Water	0.26	0.02	0.96	0.05	23.72	25.01
	Total	4014.83	46.89	2428.19	1128.32	24.10	7642.33

land from 2000 to 2010. And the conversion area of cropland was 921.12 km^2, and the conversion rate was 38.90%, among which 27.64% was converted to grassland and 10.57% to forest land. The conversion area of forest land was 13.81 km^2, and the conversion rate was 1.64%, among which 0.50% was converted to grassland and 1.03% to cropland. The conversion area of urban land was 0.81 km^2, and the conversion rate was 3.11%, among which 1.23% was converted to grassland and 1.68% to cropland. The conversion area of water was 2.78 km^2, and the conversion rate was 12.49%, among which 2.70% was converted to grassland and 8.56% to cropland. During this period, the cropland area of the Yanhe River Basin decreased significantly and most of it was converted to grassland and forest land, which was mainly related to the vigorous implementation of ecological restoration policy of returning farmland to forest (grass) since 1999. Moreover, the area of urban land began to increase compared with the previous stage, and part of grassland and cropland began to transfer to urban land, which also indicated that the growth rate of residential area in the Yanhe River Basin was accelerated and the level of urbanization was further improved. The ecological environment of the basin had achieved obvious effects through comprehensive treatment. The result was mainly due to the ecological policy of returning farmland to forest (grass) and the implementation of water conservation measures such as the World Bank loan Phase II project in the Yanhe River Basin in 2002.

According to Table 6, the conversion area of grassland was 37.14 km^2, and the conversion rate was 0.93%, among which 0.76% was converted into cropland and 0.16% into forest land from 2010 to 2015. The conversion area of cropland was 37.88 km^2, and the conversion rate was 1.56%, among which 1.3% was converted to grassland and 0.21% to forest land. The conversion area of forest land was 12.63 km^2, and the conversion rate was 1.12%, among which 0.66% was converted to grassland and 0.45% to cropland. During this period, all land use types in the Yanhe River Basin did not change significantly. But the area of forest land decreased for the first time since 2000 after the implementation of the policy of returning farmland to forest. And the urban land and water area increased slightly, which was mainly due to the large-scale development and construction in Yan'an New Area in 2012, and a lot of farmland, forest land, and grassland were used for urbanization construction.

In conclusion, the conversion rate of cropland in the Yanhe River Basin increased greatly from 1980 to 2015, indicating that cropland transferred to other land use types continuously. There was no significant change in the conversion rate of forest land, indicating that the forest land did not transfer to other land use types, and the increase of forest land mainly came from cropland and grassland. The conversion rate of grassland decreased slightly with the increase of time, indicating that the transfer rate of grassland area to other land use types became slower and slower. Moreover, the conversion rate of cropland to grassland and forest land also indicated that the area transferred from cropland to grassland was larger than that transferred from forest land.

3.3. Land Use Dynamic Attitude. According to formulas (2) and (3), dynamic land use attitudes in the Yanhe River Basin from 1980 to 2000 and from 2000 to 2015 can be obtained (Tables 7 and 8).

Tables 7 and 8 describe that 0.69% of the land use in the Yanhe River Basin changed with an average annual growth rate of 0.03%, with little overall change from 1980 to 2000. The land types with an increased dynamic land use attitude were urban land and forest land, while the land types with a negative dynamic land use attitude were cropland, grassland, and water body, respectively, indicating that the area showed a trend of continuous decrease. The most obvious increase of dynamic attitude was in urban land, up to 15.41%, with an average annual increase rate of 0.77%. The most obvious decrease of dynamic attitude was in water body, up to -7.62%, with an average annual decrease rate of 0.38%. The three main types of land use (cropland, forest land, and grassland) had no significant change in their dynamic attitude, indicating that their overall change degrees were not significant. On the contrary, during the 15 years from 2000 to 2015, 13.17% of the land use was changed, with an average annual growth rate of 0.88%, nearly 30 times of the average annual growth rate in the previous 20 years, indicating that the land use type of the Yanhe River Basin had significantly changed in the 15 years. The land use types with increasing land use attitude from large to small were urban land, forest land, and grassland, which was 75.57%, 31.45%, and 16.65%, respectively, with annual growth rates of 5.04%, 2.1%, and 1.11%, respectively. The land use types with decreased dynamic attitude to land use were cultivated land and water body (-26.24% and -0.28%, respectively), and the average annual reduction rate was 1.75% and 0.02%, respectively. It was revealed that the area of forest land and grassland in the Yanhe River Basin increased greatly during the 15 years, the area of residential land and traffic land also increased rapidly, and the area of cropland decreased greatly, which was closely related to the vigorous construction of Yan'an New Area and the remarkable achievements of ecological management in the Yanhe River Basin.

Table 7: The land use dynamic degree of the Yanhe River Basin from 1980 to 2000 (%).

	Cropland	Forest	Grassland	Water	Urban land	LC_T
K_T	-0.09	3.75	-0.85	-7.62	15.41	0.69
$K_T/20$	0.00	0.19	-0.04	-0.38	0.77	0.03

Table 8: The land use dynamic degree of the Yanhe River Basin from 2000 to 2015 (%).

	Cropland	Forest	Grassland	Water	Urban land	LC_T
K_T	-26.24	31.45	16.65	-0.28	75.57	13.17
$K_T/15$	-1.75	2.10	1.11	-0.02	5.04	0.88

3.4. Driving Forces of Land Use Change. Land use change generally refers to the underlying surface change caused by the simultaneous action of natural factors and cultural factors. Natural factors mainly include climate, soil, topography, and other aspects; cultural factors mainly include population change, economic growth, and national policies. Generally speaking, land use change caused by natural factors in a certain period is relatively weak, while cultural factors are the leading driving force for land use change [23]. This paper analyzes the driving force of land use change in the Yanhe River Basin from three aspects: population and urbanization, regional economic development, and ecological restoration and governance policies, thus revealing the causes of land use change in the Yanhe River Basin in the past 35 years, so as to provide a basis for comprehensive land resource management of the basin in the future.

Population is one of the most direct driving forces of land use change; population growth not only affects the change of agricultural products demand to influence the change of land use spatial pattern but also causes a direct impact on land use change to some extent [24]. From 1980 to 2015, the population of the Yanhe River Basin kept expanding rapidly and people's demands for residential land also increased continuously, so the area of urban land also increased significantly. At the same time, due to the development of urban surrounding areas and the construction of urban infrastructure in the basin, a large number of cropland and forest land resources were occupied and turned to urban land. In addition, as the development of science and technology and the traditional agricultural production cannot meet the needs of the people's daily life, the gradual decline of cropland was also natural. Thus, it can be seen that the large increase of population will lead to the increase of urban land and also affect the reduction of cropland.

During the 35 years from 1980 to 2015, the economy of the Yanhe River Basin developed rapidly, and the total GDP of the basin increased by more than 10 times since 2000. The continuous and rapid development of economy and the improvement of people's living quality have accelerated the change of land use type in the Yanhe River Basin. The number of people engaged in the primary industry in the Yanhe River Basin continued to decrease with the improvement of living standard, while with the rapid development of the petroleum industry and the red tourism industry in Yan'an, the proportion of the third industry in the total GDP of the basin was gradually increasing. With the development of urbanization and the adjustment of industrial structure, the construction of a large number of infrastructure needed to occupy the land resources in the basin, which promoted the change of land use type in the Yanhe River Basin.

In order to ensure the healthy and stable development of the watershed ecological environment, the Chinese government began to establish the corresponding land use policies to devote itself to the ecological restoration and treatment of the watershed environment since 1970. The Yanhe River Basin began to implement the construction of the three-north shelterbelt system and other related ecological projects in 1978; the World Food Program approved the implementation of the Integrated watershed management project of the Xingzi River which was a tributary of the Yanhe River Basin in 1988; the Yanhe River Basin Governance Project, financed by the World Bank, was born and implemented in 1994; the natural forest protection project was implemented in 1998; the project of returning farmland to forest (grass) was fully implemented at the end of 1999. The implementation of these policies in the Yanhe River Basin has caused the rapid decrease of the cropland and the large increase of forest and grassland, and the land use type has changed from agricultural production land to ecological restoration land. The ecological environment of the Yanhe River basin has been greatly improved since 2000. Therefore, the implementation of ecological restoration and governance policies is the direct driving force of land use change in the Yanhe River Basin from 1980 to 2015.

4. Discussion

In this study, remote sensing data and GIS technology are used to obtain the results of the land use change of the Yanhe River Basin from 1980 to 2015. The cropland area has been greatly reduced and has been transferred to grassland and forest land, grassland and forest land increased in a large area, and urban land continued to increase. This research result is basically consistent with the previous scholars [13, 16] in the same basin. In addition, the area of cropland and forest land in the Yanhe River Basin began to change significantly since 2000. From 2000 to 2010, the area of cropland in the basin continued to decrease, while the area of forest land and grassland increased significantly. This research result is also consistent with the previous scholar [12], indicating that ecological policies such as returning farmland to forest (grass) in the Yanhe River Basin in the past ten years have achieved obvious effects, and vegetation coverage increased significantly. From 2010 to 2015, the area of forestland in the basin decreased relatively, the decrease rate of cropland also decreased significantly compared with the previous period, and the grassland, water body, and urban land increased slightly, which was mainly related to the small scale of ecological policy of returning farmland to forest (grass) and the slow progress of project implementation.

In addition, driving force analysis is an important part of the study of land use change, and human factors are the most core driving factors among all the driving forces. Some scholars [24] have explored the land use change and driving force in the Yanhe River Basin from 1985 to 2000, but the time series was short and only factors of population, policy, and agricultural production mode were taken into account in the analysis of driving forces, while factors of socioeconomic development were not taken into account. It is clear that the adjustment of land use structure in the Yanhe River Basin is closely related to the sustained and rapid development of social economy in these 35 years by analyzing the social and economic situation of the Yanhe River Basin combined with national policies in the long time series from 1980 to 2015 in this paper. Due to the support of economic policies and the change of people's ideas, more and more people left the countryside and started to work in the secondary and tertiary industries, which is one of the important reasons for the change of land use types in the Yanhe River Basin.

At the same time, there are also many limitations in this study. Quantitative research on land use change involves some technical problems such as continuous acquisition and interpretation of multispectral remote sensing images and elimination of errors, and quantitative analysis of driving forces also requires more detailed and practical socioeconomic data, which are both difficult to complete in a practical work. Therefore, such problems need to be further considered in future researches.

5. Conclusions

Some important conclusions can be drawn from this study: (1) cropland, grassland, and forest land are the three most obvious types of land use changes, while the change of urban land and water area is relatively small. (2) It can be seen that the transfer between cropland, forest land, grassland and urban land was very obvious during 1980-2015, among which the conversion rate of cropland was the highest, forest land did not change significantly, grassland decreased slightly with the growth of time, and urban land conversion rate increased significantly since 2000. (3) During the 15 years from 2000 to 2015, the land use types of the Yanhe River Basin changed by 13.17%, with an average annual growth rate of 0.88%, indicating that the land use types of the Yanhe River Basin changed significantly. (4) In addition, the main driving forces of land use change in the Yanhe River Basin include population and urbanization; regional, social, and economic development; and ecological restoration and governance policies. The implementation of ecological restoration and governance policy is the direct driving force of land use change in the Yanhe River Basin. The results obtained in this study can provide reference basis for land use planning and management and land use structure optimization in the Yanhe River Basin in the future.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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References

[1] L. N. Wu, S. T. Yang, X. Y. Liu, Y. Luo, X. Zhou, and H. G. Zhao, "Response of land use change in the Beiluo River Basin to human activity level since 1976," *Journal of Geographical Sciences*, vol. 69, no. 1, pp. 54–63, 2014.

[2] J. Yang, G. X. Xu, J. Yao, and J. K. Luan, "Analysis of land use change and driving force in the Weihe River Basin," *Pearl River*, vol. 38, no. 7, pp. 22–26, 2017.

[3] S. S. Xiao, C. D. Wu, and J. Y. Chu, "Analysis of land use change and driving factors in Taihu Lake region from 1980 to 2005," *Transactions of the Chinese Society of Agricultural Engineering*, vol. 28, no. 23, pp. 1–11+293, 2012.

[4] B. Turner, D. Skole, S. Sanderson, D. Fischer, and R. Leemans, "Land-use and land-cover change: science/research plan," *Global Change Report (Sweden)*, vol. 43, pp. 669–679, 1995.

[5] P. H. Verburg, B. Eickhout, and H. van Meijl, "A multi-scale, multi-model approach for analyzing the future dynamics of European land use," *Annals of Regional Science*, vol. 42, no. 1, pp. 57–77, 2008.

[6] F. Lambin, H. J. Geist, and E. Lepers, "Dynamics ofland-use andland-coverchange intropicalregions," *Annual Review of Environment and Resources*, vol. 28, no. 1, pp. 205–241, 2003.

[7] K. Biro, B. Pradhan, M. Buchroithner, and F. Makeschin, "Land use/land cover change analysis and its impact on soil properties in the northern part of Gadarif region, Sudan," *Land Degradation & Development*, vol. 24, no. 1, pp. 90–102, 2013.

[8] L. Yu, W. He, Y. F. Yao, Y. Q. Huang, K. C. Huang, and L. W. Zhou, "Land use/cover change and driving force analysis in Li River Basin from multiple perspectives," *Soil and Water Conservation in China*, vol. 454, no. 1, pp. 5+44–5+48, 2020.

[9] J. Y. Liu, Z. X. Zhang, X. L. Xu et al., "Spatial pattern and driving force analysis of land use change in China in the early 21st century," *Journal of Geographical Sciences*, vol. 64, no. 12, pp. 1411–1420, 2009.

[10] J. Y. Liu, J. Ning, W. H. Kuang et al., "The spatial and temporal pattern and new features of land use change in China from 2010 to 2015," *Journal of Geographical Sciences*, vol. 73, no. 5, pp. 789–802, 2018.

[11] H. Liao, Z. K. Shu, J. L. Jin, C. G. Yang, and G. Q. Wang, "Characteristics and driving force of land use change in the Yellow River Basin from 1980 to 2015," *South-to-North Water Transfers and Water Science & Technology(Chinese and English)*, vol. 19, no. 1, pp. 129–139, 2021.

[12] H. Z. Lou, S. T. Yang, Q. W. Zhou, Y. Luo, and L. P. Hou, "Analysis of land use/cover change and driving force in Yanhe River Basin from 2000 to 2010," *Journal of Arid Land Resources and Environment*, vol. 28, no. 4, pp. 15–21, 2014.

[13] W. S. Zhang, F. Wang, X. M. Mu, R. Li, and Y. He, "Spatial-temporal characteristics of land use/cover change in the Yanhe River Basin in recent 25 years," *Research of Soil and Water Conservation*, vol. 19, no. 5, pp. 148–152+157+291, 2012.

[14] H. X. Xie, Q. K. Yang, R. Li, X. P. Zhang, L. Cheng, and G. W. Pang, "Analysis of erosion reduction effect of soil and water conservation measures in the Yanhe River Basin," *Science of Soil and Water Conservation*, vol. 8, no. 4, pp. 13–19, 2010.

[15] J. P. Li, F. Wang, X. M. Mu, and Q. K. Yang, "Effects of land use change on ecological service value in the Yanhe River Basin," *Research of Soil and Water Conservation*, vol. 17, no. 3, pp. 110–114, 2010.

[16] S. H. Ran, K. Zhang, and C. H. Lu, "Scale transformation method of land use/cover change model in the Yanhe River Basin," *Progress in Geography*, vol. 29, no. 11, pp. 1414–1419, 2010.

[17] C. Z. Li, H. Wang, F. L. Yu, A. M. Yang, and D. H. Yan, "Effects of soil and water conservation on runoff and sediment in the Yanhe River Basin," *Science of Soil and Water Conservation*, vol. 9, no. 1, pp. 1–8, 2011.

[18] J. J. Wei, X. P. Li, Q. K. Yang, and W. Liang, "Research on spatio-temporal change of land use and conversion of farmland to forest based on remote sensing – a case study of the lower reaches of the Yanhe River Basin," *Bulletin of Soil and Water Conservation*, vol. 27, no. 2, pp. 87–90, 2007.

[19] H. X. Xie, R. Li, Q. K. Yang, J. Li, and W. Liang, "Effects of returning farmland to forest (grassland) and rainfall changes on soil erosion in the Yanhe River Basin," *Scientia Agricultura Sinica*, vol. 42, no. 2, pp. 569–576, 2009.

[20] F. P. Ren, Y. Jiang, X. Xiong, M. Y. Dong, and B. Wang, "Analysis of spatial-temporal differences in land use changes in the Dongjiang River Basin in recent 20 years," *Resources Science*, vol. 33, no. 1, pp. 143–152, 2011.

[21] L. Cheng, Z. X. Xu, R. Luo, and Y. J. Mi, "Spatial and temporal variation characteristics and driving force analysis of LUCC in Weihe River Basin from 1980 to 2000," *Research of Soil and Water Conservation*, vol. 16, no. 5, pp. 1–6+30+287, 2009.

[22] W. Li, J. Chen, L. Li, and H. Chen, "Analysis of land use change in the Yangtze River Basin from 1980 to 2015," *Yangtze River*, vol. 51, no. 2, pp. 49–57, 2020.

[23] J. Ren, J. Y. Jiang, Z. H. Zhao, L. Xu, and M. Cheng, "Study on land use/cover change and driving force in Yili Basin from 1980 to 2015," *Science Technology and Engineering*, vol. 20, no. 21, pp. 8480–8488, 2020.

[24] H. F. Zhu, W. W. Zhao, M. Y. Kang, and W. W. Guo, "Spatial and temporal changes of land use patterns and driving factors in the Yanhe River Basin," *Journal of Arid Land Resources and Environment*, vol. 22, no. 8, pp. 17–22, 2008.