Trends in the value of ecosystem services in Zhangjiakou City Research

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Abstract

This paper analyzes the structural and pattern changes of land use based on the land use monitoring data of Zhangjiakou area, uses GIS spatial analysis to estimate the vegetation cover in the study area, and applies the equivalent factor method to assess the ecosystem service values before and after the land use type changes in Zhangjiakou city during 2015-2020. The results showed that the value of ecosystem services in Zhangjiakou City in 2015 was 5,364,015,000 RMB, and the value of ecosystem services in 2020 was 5,954,552,000 RMB, an increase of 11% compared to 2010. The comprehensive land use index increased from 245.253 in 2010 to 251.865 in 2020, with time, the area of arable land, forest land and grassland in Zhangjiakou increased, and the area of other agricultural land and unused land was decreasing; in general, the degree of land use covered by vegetation in Zhangjiakou was in an elevated state, and the overall tendency was toward non-agricultural use, and the amount of unused land decreased significantly.

Keywords

Ecosystem, Land type, Wetland, Service value.

1. Introduction

Ecosystems are the basis for human economic and social development and provide important ecological assets for human society. Ecosystem services are the natural environmental conditions and utilities created by ecosystems and ecological processes that sustain human survival.[0] In modern society, humans are facing more and more ecological risks and threats, to a large extent as a result of impaired ecosystem functions and services. The value of ecosystem services can be reflected both at the level of ecological architecture and in the economic and social impacts on humans. Therefore, conducting research and evaluation on the value of ecosystem services can not only provide a deeper understanding of ecosystems at the economic and social levels, but also identify potential risks in ecosystems, thus providing reasonable suggestions for solving problems and remedying defects. In this paper, we will apply the dynamic attitude model of single land use type, transfer matrix, land use/cover change state index and overall trend model, ecosystem service value calculation model, ESV to VC sensitivity model, single service function value calculation model, impact degree model, and ecological service value flow analysis model for Zhangjiakou city.

2. Overview of the study area and data sources

2.1. Study Area Overview

Zhangjiakou City is located in the northwest of Hebei Province, east of Chengde City, Hebei Province, southeast of Beijing, south of Baoding City, Hebei Province, west and southwest of Shanxi Province, north and northwest of the border with Inner Mongolia Autonomous Region , between 113°50'E ~ 116°30' E, 39°30'N ~ 42°10' N, the maximum length of 300km from north to south, the maximum width of 228km from east to west, land The total land area is 36,800km^2 ,

ISSN: 1813-4890

the elevation range of the city is 320 ~ 2841km, and the terrain slopes from northwest to southeast. The Yinshan Mountain Range divides Zhangjiakou into two different geomorphic units. The plateau area above the dam accounts for 1/3 of the total area of the city, with an average elevation of about 1,500 m. It is characterized by a mixed distribution of hills, lakes, mudflats and grass slopes. The undulating plateau and hills are the main types of landforms; the basin area below the dam has an average altitude of about 700 m, with the Yanghe Basin, Huai Zhuo Basin, and Weixian-Yangyuan Basin distributed among the mountains.[2] The climate is temperate continental monsoon. The climate is temperate continental monsoon climate with an average temperature of about 7.8℃, high temperature and rain in summer, low temperature and dryness in winter, and an average precipitation of 350 mm per year, which is concentrated in May-August.[3] Its precipitation decreases from southeast to northwest. The vegetation types in Zhangjiakou area are rich, and the natural vegetation is mainly scrub and sprouting dwarf forest, grassland and sparse shrub grassland; the agricultural vegetation is mainly annual cereal crops and hardy cash crops.[4] The agricultural vegetation is mainly annual cereal crops and hardy cash crops.

2.2. Data source

The main sources of data in this paper are the Zhangjiakou Economic Yearbook (2010-2020), Hebei Statistical Yearbook (2010-2020), the website of the Natural Resources and Planning Bureau of Zhangjiakou City, and the GlobeLand30 surface coverage data (2015, 2020) organized and published by the Ministry of Natural Resources of China.

3. Research Methodology

3.1. Analysis of land use types

Relying on ArcGIS platform, the land use data of Zhangjiakou City for two periods of 2010 and 2020 were calculated to derive the changes of land use types in Zhangjiakou area, and then analyze the impact of land use changes on the value of ecosystem services. The land use type map of Zhangjiakou city area was also produced by combining GlobeLand30 ground cover data and using Arcgis analysis. (Figure 1, Figure 2)

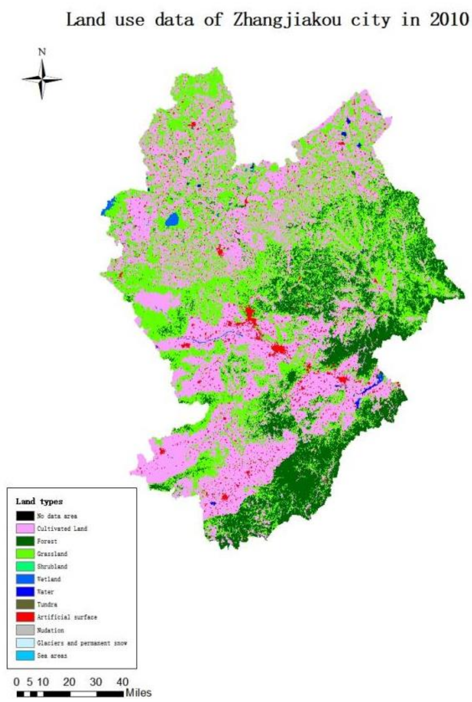

Figure 1 Land use type of Zhangjiakou City in 2010

ISSN: 1813-4890

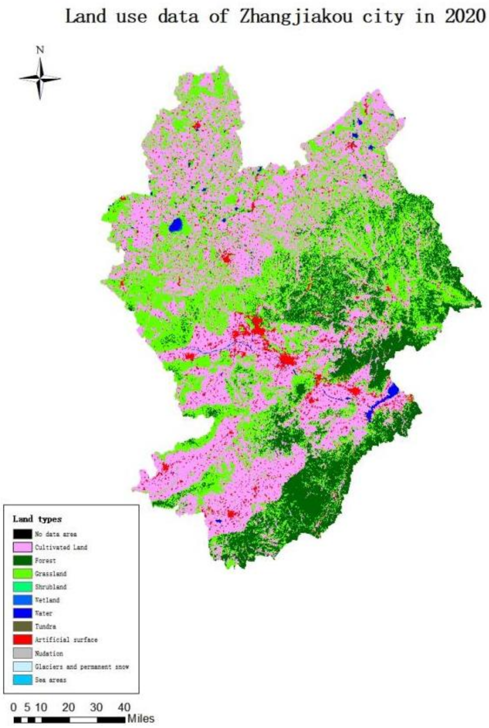

Figure 2 Land use type of Zhangjiakou City in 2020

3.2. Dynamic analysis of land use type transition

This study combines the spatial analysis function of GIS to analyze two parts of TM images from 2015 and 2020, and after statistical calculations, the land use types belonging to different periods in 2015 and 2020 are derived, and from this analysis, the structural and pattern changes of land use are analyzed. From Table 1, it can be seen that the main land use types in 2015 are grassland, cropland and woodland; while in 2020, they change to cropland, building land, woodland and grassland. To summarize the land use types and structural quantities in Zhangjiakou region in 2020, the dynamic changes are characterized as follows: the largest increase is in the area of arable land and construction land; in contrast to the increase in arable land and construction land, the area of grassland continues to decrease significantly; there are also large changes in watershed, forest land and unused land. It can be seen that the land use status of Zhangjiakou area has changed considerably in these two periods.

Table 1 Changes in land use types in Zhangjiakou area in 2015 and 2020 Unit: ha

Land Use Type		Land use classification area		Change in area from 2015-2020
		2015	2020	
Total land area		3679671.732	3679698.398	26.667
Agricultural land	Arable land	932057.994	972944.865	40886.871
	Woodland	1099472.164	1347226.736	247754.572
	Garden	142674.047	142994.048	320.002
	Grassland	240981.205	269174.679	28193.474
	Agricultural land in other districts	82153.744	81060.405	-1093.339
	Total	2497339.153	2813400.734	316061.580

	agricultural land			
Construction land (including water and water facilities)	Water bodies	56300.282	57400.287	1100.006
	Other	106753.867	113360.569	6606.700
	Total	163054.149	170760.854	7706.705
Unused land		1019271.763	695536.811	-323734.952

Table 2 Land Use Type Transfer Matrix for Zhangjiakou City, 2010-2020 Unit: ha

2010 / 2020	Arable land	Forest	Grassland	Shrubs	Wetlands	Water bodies	Artificial	bare ground	Total
Arable land	18161.168	84.713	1188.612	3.218	2.946	58.914	560.715	0.432	20060.718
Forest	111.933	6691.520	1062.254	8.447	1.774	11.046	13.195	0	7900.169
Grassland	1913.307	1025.755	13705.494	24.385	1.455	25.561	224.131	0	16920.088
Shrubs	9.082	9.828	24.319	10.775	0.013	0.428	2.768	0	57.211
Wetlands	2.786	0.181	41.733	0.014	35.353	86.578	0.628	0	167.274
Water bodies	2.323	0.406	4.080	0.086	0.114	93.910	0.422	0	101.340
Artificial	124.574	1.627	40.005	0.442	0.032	2.075	1082.351	0	1251.104
bare ground	7.119	0.033	0.185	0.000	0.000	0.000	0.413	0	7.750
Total	20332.292	7814.063	16066.681	47.367	41.686	278.510	1884.623	0	46465.655

3.3. Analysis of land use degree change

The comprehensive land use intensity index reflects the intensity of utilization of all land use components in a given year. It allows a quantitative analysis of the use of urban land, so as to determine the overall condition and changing trend of urban land use[5] It is an important indicator to measure the land use situation in the region. By establishing a mathematical model for the land use indicators in Zhangjiakou area, the mathematical method can be applied to obtain a continuously distributed composite index, which can be used to reflect the degree of land use in the area, with the following model:

$$L_a = 100 \times \sum_{i=1}^{n} A_i C_i$$

Where, L_a denotes the number of comprehensive land use index of Zhangjiakou area; A_i denotes the graded index of land use at level i of the area; C_i denotes the graded area percentage of land use at level i of the area; n denotes the graded number of land use in the area.[6] .

3.4. Ecosystem service value assessment

To assess the value of ecosystem services in the Zhangjiakou area, we used the analytical model developed by Costanz R et al.[7] To assess the value of ecosystem services in Zhangjiakou, we used the analytical model invented by Costanz R et al. for the value of ecosystem services and the calculation method for the unit area equivalent in China proposed by Xie Heights et al.[9] We used the model developed by Costanz R et al.

3.4.1. Determination of equivalence factors for standard ecosystem service values

In this study, the equivalent factor method of unit area value was used to[8] In this study, the value of ecosystem services in Zhangjiakou City was estimated by the equivalent factor method of unit area value.[9] In 2003, Xie Gaoqi, a scholar in China, drew on Costanza's research results and revised the table of ecosystem service values in the form of a questionnaire suitable for use in terrestrial ecosystems in China (Table 3).

Table 3 Table of terrestrial ecosystem service value equivalence factors in China

Ecosystem service type	Desert	Farmland	Wetlands	Water bodies	Woodland	Grassland
Food supply	0.01	1	0.30	0.10	0.10	0.30
Raw material production	0	0.10	0.07	0.01	2.60	0.05
Climate regulation	0	0.89	17.10	0.46	2.70	0.90
Water Harvesting	0.03	0.60	15.50	0.38	3.20	0.80
Gas Regulation	0	0.50	1.80	0	3.50	0.80
Soil conservation	0.02	1.46	1.71	0.01	3.90	1.95
Waste disposal	0.01	1.64	18.18	18.18	1.31	1.31
Biodiversity	0.34	0.71	2.50	2.49	3.26	1.09
Culture and Entertainment	0.01	0.01	5.55	4.34	1.28	0.04

Since the biomass in Zhangjiakou area differs from the 2003 standard national biomass per unit area of a primary ecosystem, it needs to be corrected again with the formula.

$$VC_{ij} = (b_j / B) \times P_i \quad i = 1, 2 \ldots 9 \quad j = 1, 2 \ldots n$$

where VC_{ij} represents the revised value of ecosystem services per unit area, and **i represents the** value corresponding to the type of ecosystem services; **j** represents the different types of ecosystems; P_i represents the baseline unit price of the value of services of different ecosystems; b_j represents the biomass in type **j** ecosystems, and **B** is the average biomass per unit area in our primary ecosystem types.[9] . Substituting the data into the statistical model above, we can obtain a statistical table of ecosystem unit values with a high degree of academic recognition: (Table 4)

Table 4 Table of ecological service values per unit area of different terrestrial ecosystems in China Unit: Yuan/hm^2

	Forest	Grassland	Farmland	Wetlands	Water bodies	Desert
Temperature conditions	309700	70790	44240	159270	0	
Climate regulation	238910	79640	78750	1513090	40700	

Water Harvesting	283150	70790	53090	1371520	1803320	2650
Soil formation and conservation	345090	172550	129190	151310	880	1770
Waste disposal	115920	115920	145120	1608660	1608660	880
Biodiversity Conservation	288460	96450	62820	221220	220330	30080
Food production	8850	26550	88490	26550	8850	880
Raw Materials	230060	4420	8850	6190	880	
Entertainment Culture	113260	3540	880	491090	384020	880
Total	1933400	640650	611430	5548900		37140

3.4.2. Calculation of ecosystem service values

We model the estimation of the value of ecosystem services:

$$VC_j = Ef_{vj} \times C$$

$$ESV = \sum_{j=1}^{n} \left(A_j \times VC_j \right)$$

In the model, VC_j denotes the service value factor of ecosystem for land of type j (\$/hm^2); Ef_{vj} denotes the equivalent of the service value of ecosystem for land use type j after correction; C denotes the equivalent factor of service value of a standard unit of ecosystem; ESV is the total ecosystem service value (\$); A_j (hm^2) is the area of land use type j[9] .

3.4.3. Ecosystem vegetation cover contribution study

In this study, the vegetation cover index (NDVI) was used to reflect the surface vegetation cover in Zhangjiakou area in recent years. NDVI time-series data derived from Spot/Vegetation and Modis satellite remote sensing images are widely used for monitoring vegetation dynamics, detecting land use/cover changes, macro-dynamic classification of vegetation, and estimation of net primary productivity.[10] NDVI values range from -1 to 1, where a negative value indicates that the ground cover is cloud, water, snow, etc., which is highly reflective of visible light; 0 indicates rock or bare soil, etc.; and a positive value indicates that vegetation cover is present and increases with increasing cover.[11] .

4. Results and Analysis

4.1. Analysis of the change in the composite index of land use degree

We evaluate the breadth and depth of land use in Zhangjiakou through the comprehensive land use index La , which is 245.253 in 2010 and 251.865 in 2020. Accordingly, it is concluded that the degree of land use in Zhangjiakou is on an upward trend and the general direction is toward non-agricultural use, with a significant reduction in the amount of unused land. At the same time, combining economic and social factors, it is found that the productivity of the countryside has been greatly improved, thus releasing more rural laborers, while more people are involved in non-agricultural production, the area of land for construction has greatly increased, and the amount of unused land has greatly decreased, indicating that human beings are using land more efficiently and more scientifically.

4.2. Calculated valuation of ecosystem service values

4.2.1. Calculation of ecosystem service values

The calculation of ecosystem service value is based on the correlation between land use types and ecological service functions, and matching land with different use types with various ecosystems according to the principle of consistent or close service functions: forest land corresponds to forest ecosystems; cropland corresponds to farmland ecosystems; grassland corresponds to grassland ecosystems; reservoirs, rivers and lakes correspond to water body ecosystems; unused land is mostly covered by The ecological service function of garden land is higher than that of grassland ecosystem but lower than that of forest ecosystem, so its value is set as the arithmetic mean of forest ecosystem and grassland ecosystem; construction land includes urban, rural, industrial and mining land, transportation land, etc. In recent years, some domestic scholars have classified it as construction land independently. However, its ecological service function is limited, so it is regarded as desert ecosystem in the data processing.[12] However, its ecological service function is limited, so it is treated as desert ecosystem.

Table 5 Table of ecological service value per unit area of Zhangjiakou ecosystem Unit: Yuan/hm^2

Land Use Type	Arable land	Garden	Grassland	Woodland	Rivers, lakes, water	Construction Land	Utilized land
Corresponding Ecosystems	Farmland	Forests, meadows	Grassland	Forest	Water bodies	Desert	Grassland
Value of ecological services	8964.94	18870.64	9393.35	28347.92	59640.60	544.92	5636.01

The ecosystem service values of each land use type in Zhangjiakou City from 2015-2020 can be obtained by substituting the land area of each type counted in the previous section into the ecosystem service value calculation formula. (Table 6)

Table 6 Statistics on the value of ecosystem services in Zhangjiakou City in 2015 and 2020 Unit: million yuan

Year	Arable land	Woodland	Garden	Grassland	Water	Construction Land	Utilized land	Total Value
2015	8355.84	31167.75	2692.35	2263.62	3357.78	58.17	5744.63	53640.15
2020	8722.39	38191.08	2698.39	2528.45	3423.39	61.77	3920.05	59545.52

ISSN: 1813-4890

4.2.2. Study on the degree of contribution of each land use type to the value of ecosystem services in Zhangjiakou City

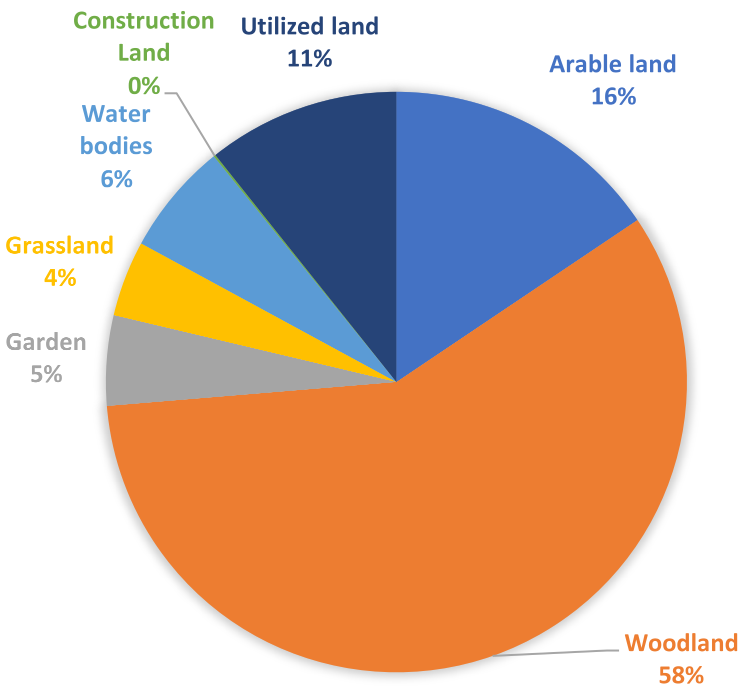

Figure 3 Schematic diagram of the contribution of ecosystem service values in Zhangjiakou City in 2015

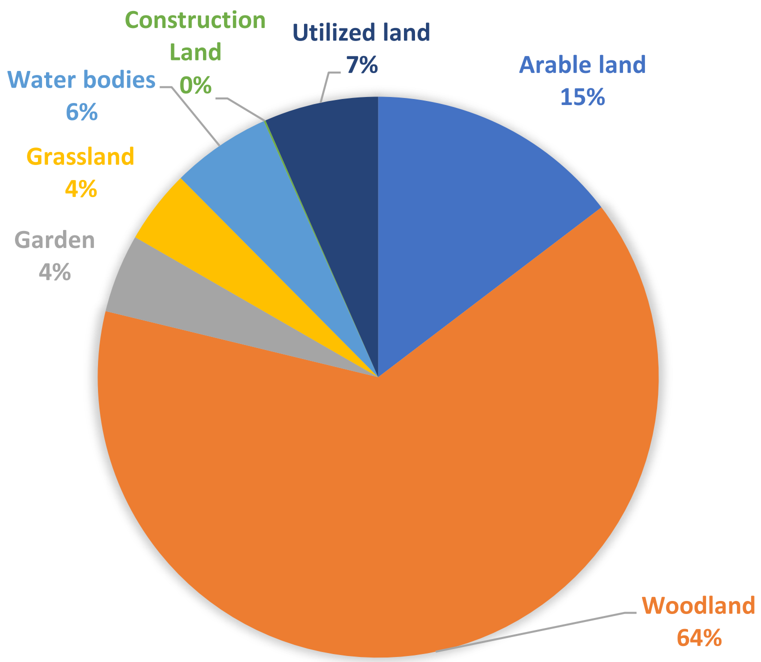

Figure 4 Schematic diagram of the contribution of ecosystem service values in Zhangjiakou in 2020

The value of ecosystem services in 2015 is 5,364,015 million yuan and in 2020 the value of ecosystem services is 5,954,552 million yuan, an increase of 11% compared to 2010. From Figure 3 and Figure 4 we conclude that forest land has the largest contribution to the value of ecosystem services in Zhangjiakou City, reaching 58% in 2015 and 64% in 2020. In recent years,

ISSN: 1813-4890

Zhangjiakou City has taken afforestation as the main strategic project to build a water-containing function area and an ecological environment support area for the capital, and at the same time to create a good ecological environment for the Winter Olympic Games competition area, Zhangjiakou has implemented the "Green Development Life Project", and the city has promoted afforestation on a large scale . From 2015 to 2020, the city will rely on This key project will afforest 247,754 hectares and increase the forest coverage rate to 50%, making it a model of green development in the semi-arid region where agriculture and animal husbandry are intertwined. Unexploited land was reduced by 323,435 hectares between 2015 and 2020, significantly reducing the rate of land abandonment. In particular, during the construction of the Winter Olympics branch venue in Zhangjiakou, the Zhangjiakou competition area implemented ecological restoration in a gradual manner according to the plant growth characteristics of the area and restored the site plants, with a restoration area of 454,000 square meters. Among them, in order to reduce the disturbance to the surrounding ecosystem, Genting Ski Park paid great attention to environmental protection and ecological restoration during the construction process. The race track and the surrounding areas are restored by different vegetation restoration methods according to the different soil quality and slope of the site.

4.2.3. Study on the value of important ecosystem functions and services in Zhangjiakou City

Table 7 Service values of important ecosystem functions in Zhangjiakou City

Ecosystem functions		Value of services (x $10^{8})	
		2015	2020
Supply Services	Food production	11.5199	11.7352
	Raw material production	26.5851	32.2373
Reconciliation Services	Gas Regulation	48.9966	54.5718
	Climate regulation	122.3650	105.2915
	Water Harvesting	126.7144	112.9180
Support Services	Soil conservation	62.9874	70.1403
	Maintaining nutrient cycles (waste disposal)	130.2908	109.2006
	Biodiversity	56.8639	60.1476
Cultural Services	Aesthetic Landscape	42.9817	38.1737

As shown in Table 7, the service values of water connotation, maintenance of nutrient cycling, climate regulation, soil conservation, biodiversity, gas regulation, aesthetic landscape, raw material production, and food production of Zhangjiakou City ecosystem decrease in order from 2015 to 2020.

In terms of the functions of the ecosystem in Zhangjiakou, the core ecosystem service values in the region are regulating services and supporting services, accounting for 86%, with regulating services accounting for 46% and supporting services accounting for 40%; in addition, supply services account for 8% and cultural services account for 6%. From 2015 to 2020, the proportion of each ecosystem service in Zhangjiakou City changes less and remains stable, indicating that there is no significant change in various land use types.

The value of soil conservation services of the ecosystem increased the most. The functions of water conservation, climate regulation, and waste treatment have decreased significantly, and we speculate that this phenomenon is related to the serious wetland degradation in

Zhangjiakou. Zhangjiakou is a typical inland type wetland, where the climate is dry and the phenomenon of river breakage is very serious. In addition, due to unreasonable human cultivation, the original vegetation in this area has been greatly damaged, the soil shows a tendency to desertification, soil and water conservation capacity has decreased, and the wetland area is shrinking. At the same time, the role of wetlands in water conservation, climate regulation and waste disposal has also been weakened.

4.2.4. Study on the change of vegetation cover in Zhangjiakou City

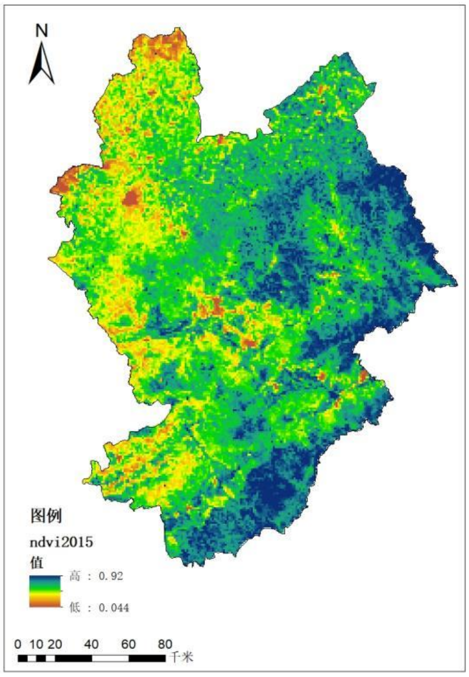

Figure 5 Vegetation index map of Zhangjiakou City in 2015

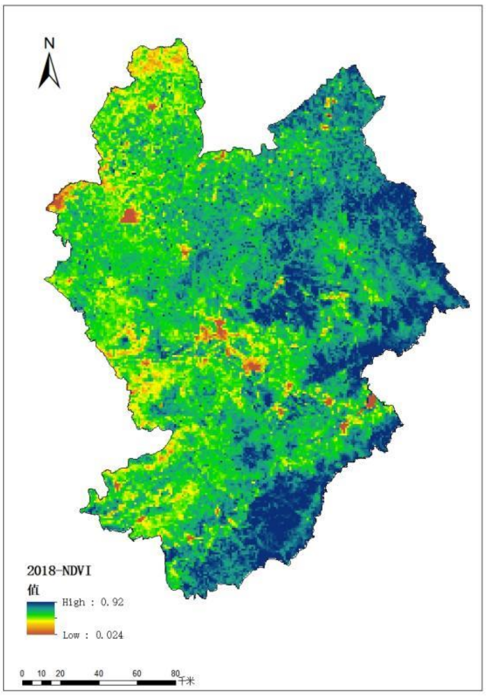

Figure 6 Vegetation index map of Zhangjiakou City in 2018

Using the data set of annual vegetation index (NDVI) spatial distribution in China provided by the Resource and Environmental Science Data Registration and Publication System[10] , we obtained the vegetation index maps of Zhangjiakou city in 2015 and 2018 (resolution 1 km × 1 km). From Fig. 5 and Fig. 6, it can be concluded that the overall vegetation cover of Zhangjiakou

City from 2015-2018 showed an increasing trend and local areas were degraded, which is the reason why the lowest value of NDVI in the figure decreased from 0.044 to 0.024. The growth of vegetation cover is more obvious in the northwestern and southwestern areas, and the areas with NDVI values below 0.5 are significantly reduced.

5. Discussion and Recommendations

Taking the Beijing Winter Olympic Games as an opportunity, Zhangjiakou has accelerated its economic transformation and built the "Beijing-Zhangdong Sports and Cultural Tourism Belt", which will stabilize the regional ecological environment and improve ecological service functions during the period of 2015-2020. Zhangjiakou is in a special location and has a special responsibility to protect the water resources and ecological environment of Beijing. Especially in the pre-Winter Olympic Games period, the dam area vigorously implemented fallowing, and wheat, oat and other grain crops were replaced by endless grassland and woodland. Zhangjiakou City's water environment is also improving, with 100% water quality standards; forest coverage has also increased from 39% to 50%, and the area is vigorously maintaining and expanding wetland parks, with an area of up to 680,000 mu. Zhangjiakou City has gradually embarked on the road of ecological development and green development based on the transformation of hair.

However, while Zhangjiakou City is generally moving in a good direction, it should also strengthen the protection and restoration of wetlands. Wetlands are the areas with the richest biodiversity and are related to the future and development of human beings. In general, the condition of wetlands in China is in a poor state. The results of the wetland resources survey published by the State Forestry Administration show that[13] The results of the wetland resource survey published by the State Forestry Administration show that about 94% of the natural wetlands in China are showing a serious degradation trend, which is manifested by the decline of ecological regulation function, biodiversity and productivity, causing great security risks to the natural environment and social development.[14] This is a great security risk to the natural environment and social development. The factors leading to the degradation of wetlands are social, natural and other aspects, which are characterized by the complexity of the synergistic effect of multiple factors.[15] It is characterized by the complexity of the synergy of multiple factors. For the restoration of wetlands, we propose the following recommendations:

(1) Guarantee water for wetland ecology

A large number of reservoirs have been built in the dammed areas of Zhangjiakou for flood control and irrigation. However, due to climate change, the functions of many reservoirs have largely failed. Therefore, it is necessary to dismantle the reservoirs that have lost their functions and dredge waterways to guarantee the recharge of wetlands.

(2) Improve the groundwater management system

The water resources in the dam area are short, and the agricultural water use exceeds the standard, and the waste of water resources is even more serious. Therefore, the management system of groundwater source exploitation should be improved to prevent the groundwater level from falling too fast.

(3) Vigorously develop wetland restoration projects

Natural restoration is the main focus, supplemented by artificial restoration. For wetlands with more serious human interference, wetland parks can be established to reduce human damage. For man-made interference with dead plants, artificial replanting to ensure that the wetland ecosystem to maintain its proper ecological function.

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