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Impacts of climate change and afforestation on NDVI in the Yan'an City, China

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Abstract

The vegetation index of Yan'an City from 2000 to 2019 was between 0.54 and 0.75, showing a significant upward trend in the time distribution, with an overall rising rate of 0.095/(10a); from 2000 to 2019, 79.83% of the regional vegetation in Yan'an City Shows an improvement trend, mainly distributed in the loess beam and gully areas in the north and east of Yan'an City. The degraded area accounts for 0.34% of Yan'an City. It is mainly distributed in the suburbs of Yan'an city and county-level cities, showing dots and stripes. Banded distribution; from 2000 to 2012, human activities were the dominant factor in determining the status of the vegetation index, and the main factor affecting the growth of vegetation in Yan'an from 2013 to 2019 was water and heat conditions. In summary, the vegetation index of Yan'an City is showing an upward trend, and the national policy of returning farmland to forest and grassland has made great achievements and improved the overall ecological environment of Yan'an City.

Keywords

Yan'an City, NDVI, MOD13A1, trend line analysis.

1. Introduction

Vegetation is an important medium for energy exchange, water cycle and carbon cycle on the earth's surface, and plays an important role in global energy balance and climate change [1-2]. Vegetation is also an indicator of the stability of the regional ecosystem, and has the functions of improving the climate, fixing water and soil, and reducing pollution [3]. In addition, the vegetation in arid areas is extremely sensitive to climate change and water and heat conditions. Therefore, exploring the process of regional vegetation change has important guiding significance in the improvement of the ecological environment and the utilization of biological resources [4-5]. The Loess Plateau is one of the most vulnerable areas in China's ecosystem. In the early years, due to excessive land reclamation, vegetation coverage declined sharply, and problems such as soil erosion and land desertification became increasingly prominent [6-7]. After years of implementation of the project of returning farmland to forest and grassland, the ecological environment of the Loess Plateau has been continuously improved. Yan'an City, as a typical area of ecological conversion of farmland on the Loess Plateau, is located in the central and southern part of the Loess Plateau. Under the background of ecological conversion of farmland, the vegetation coverage of Yan'an City has undergone tremendous changes. However,

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affected by natural factors and human activities, the ecological environment of Yan'an City is still fragile. Therefore, probing into the dynamic changes of vegetation in Yan'an and its relationship with precipitation and temperature is of great significance for guiding the coordinated development of social economy and ecological environment in Yan'an.

This study takes Yan'an City as the research area, based on MODIS13 NDVI data, comprehensively uses the maximum value synthesis method and trend line analysis method to analyze the dynamic changes of the vegetation index in Yan'an City from 2000 to 2019, and combines the precipitation and temperature in the research area. And other meteorological elements, explore the factors that affect the vegetation changes in the region, and provide a scientific reference for the regional ecological environment protection.

2. Data source

MOD13A1 data is a level 3 product of MODIS data. Its content includes the global normalized vegetation index (NDVI), with a spatial resolution of 500 m and a time resolution of 16 d, with a total of 23 scenes per year, where 001 represents the daily sequence. The maximum composite value of NDVI from 1 to 16 days. The MOD13A1 data selected in this study contains NDVI data from January to December 2000 to 2019 (the data for January 2000 is missing), and the row number is h26v05. Two images can be obtained every month, and the average value of the two is used as the vegetation index of the month. The meteorological data comes from the China Meteorological Data Network (https://data.cma.cn/). There are 4 national meteorological stations in the study area, namely Yan'an Station (54845), Yanchang Station (53854), Luochuan Station (53942)) And Wuqi Station (53738), select the daily precipitation and temperature data of each meteorological station from 2000 to 2018 (meteorological data for 2019 are not yet available), and obtain the annual average value of precipitation and temperature in Yan'an City through sorting and calculation.

3. Results and analysis

3.1. Spatio-temporal change characteristics of vegetation index in Yan'an City

Figure 1 shows the inter-annual change trend of NDVI in Yan'an from 2000 to 2019. From 2000 to 2019, the annual average NDVI in Yan'an was between 0.54 and 0.75, showing a significant growth trend overall, with a growth rate of 0.095/(10a). Among them, from 2000 to 2012, the annual average value of NDVI in Yan'an City maintained a rapid upward trend, while from 2012 to 2019, the average annual NDVI value fluctuated greatly and the growth rate was slow, and it appeared extremely low in 2015. The reason is that since 1999, Yan'an City began to implement the project of returning farmland to forest and grassland. Humans planted large areas of woodland and grassland, which increased the vegetation coverage of Yan'an City, and made Yan'an City a significant increase in vegetation index from 2000 to 2012. However, after 2012, the government has focused on protecting vegetation from damage. Natural environmental factors have a leading role in the growth of vegetation in Yan'an, so the growth rate of its vegetation index has slowed down.

Count the area and proportion of different NDVI intervals in each year (Table 1). It can be seen from the table that the vegetation index of Yan'an City is showing an upward trend. Compared with 2000, the area with an NDVI value of less than 0.5 in 2010 decreased significantly, and the vegetation index of the whole Yan'an City showed an improvement trend. Compared with 2010, the vegetation index of Yan'an City continued to increase in 2019. Some areas with moderate vegetation coverage were transformed into areas with high vegetation coverage. Affected by urban construction, the type of land cover changed from grassland and cultivated land to construction land, reducing vegetation cover.

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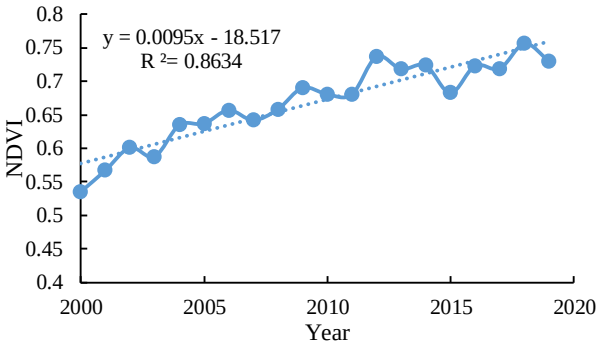

Figure 1: The interannual change trend of NDVI in Yan'an City from 2000 to 2019

Table 1: The area and proportion of different NDVI intervals in Yan'an City in 2000, 2010 and 2019

NDVI	2000		2010		2019	
	Area/km2	Proportion	Area /km2	Proportion	Area /km2	Proportion
< 0.3	1 685.2	4.55%	22.2	0.06%	33.3	0.09%
0.3 - 0.4	9 888.9	26.70%	170.4	0.46%	100.0	0.27%
0.4 - 0.5	8 077.8	21.81%	2 744.4	7.41%	737.0	1.99%
0.5 - 0.6	4 400.0	11.88%	9 418.5	25.43%	4 459.3	12.04%
0.6 - 0.7	3 877.8	10.47%	8 063.0	21.77%	10 429.6	28.16%
0.7 - 0.8	6 155.6	16.62%	7 225.9	19.51%	9 233.3	24.93%
0.8 - 1.0	3 322.2	8.97%	9 392.6	25.36%	12 048.1	32.53%

In order to further analyze the dynamic changes of vegetation in the study area, this study uses the trend line analysis method to study the spatial change trend of the vegetation index in Yan'an from 2000 to 2019. Table 2 shows the area and proportion of each change slope interval. The vegetation index in the study area shows an overall upward trend. Among them, 79.83% of the regional vegetation shows an improvement trend, covering an area of 29 568.3 km2, mainly distributed in the loess beam and gully areas in the north and east of Yan'an City. In key areas where forests and grasses are restored, the ecology has been effectively restored after years of management. Degraded areas accounted for 0.34% of Yan'an City, with an area of 125.4 km2, mainly distributed in the suburban areas of Yan'an City and county-level cities. They are distributed in dots and strips. The reason is analyzed due to the rapid development of urbanization and soil utilization. The type changed from grassland and cultivated land to construction land, and NDVI showed a significant trend of degradation.

Table 2: The area and proportion of different NDVI trends

NDVI change trend	2000—2019	
	Area/km2	Proportion
Severely degraded	25.3	0.07%
Moderate degradation	100.1	0.27%
Basically unchanged	7 343.2	19.83%
Moderate improvement	10 774.0	29.09%
Highly improved	18 794.3	50.74%

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3.2. Analysis of influencing factors of vegetation index

3.2.1. The relationship between NDVI and natural factors

Analyzing the inter-annual distribution of NDVI and temperature and precipitation in Yan'an from 2000 to 2019 (Figure 2), it is found that the correlation between NDVI and temperature and precipitation from 2000 to 2012 is poor, and there is a negative correlation between temperature and NDVI. The reason is that in 1999 Yan'an City began to implement the project of returning farmland to forests and grasslands. During this period, human activities are the dominant factor in determining the status of the vegetation index and are less affected by natural factors. From 2013 to 2019, the change trend curve of the vegetation index in Yan'an City was basically consistent with temperature and precipitation, and the three showed extremely low values at the same time in 2015, indicating that after 2013, the main factor affecting the growth of vegetation in Yan'an is water and heat conditions.

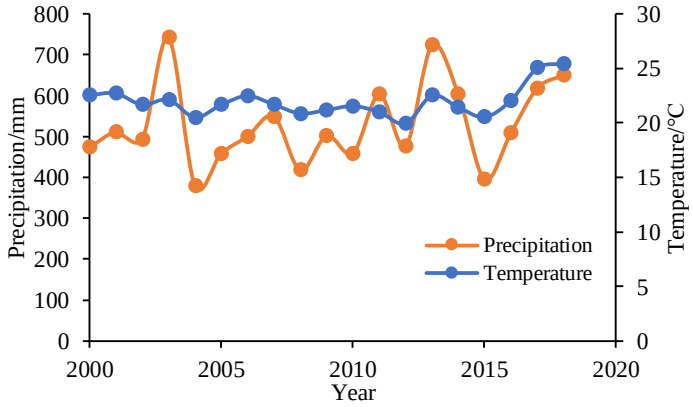

Fig. 2 Variation curve of NDVI and annual precipitation and annual temperature in Yan'an from 2000 to 2019

3.2.2. The relationship between NDVI and human activities

Since the end of the 20th century, the state has implemented projects to prevent soil degradation and soil erosion, such as returning farmland to forests and grasslands, flood diversion and silting land, and treatment of steep slopes. Yan'an City actively responded to the national project and implemented an ecological policy of returning farmland according to land use types and natural environmental conditions. After the implementation of the ecological restoration project, the ecological environment of Yan'an City has gradually turned into a benign transformation, ensuring the stability of the natural surface, and the comprehensive management of soil erosion has increased by more than 25%. Effectively promote the growth of woodland and grassland, and the vegetation index of Yan'an City has been significantly improved. However, there are still some areas of Yan'an urban area and the surrounding cities of counties where the vegetation is seriously degraded. The reason is the rapid development of urbanization. Therefore, in order to ensure the stability and quality of human living environment, the government and people need to continue to maintain the ecological environment. We will not relax our protection efforts, follow the path of coordinated development of the social economy and the ecological environment, and regard the restoration of vegetation as a long-term commitment.

4. Conclusion

The vegetation index of Yan'an City from 2000 to 2019 was between 0.54 and 0.75, showing a significant upward trend in terms of time distribution. Its NDVI value increased from 0.54 in 2000 to 0.73 in 2019, and the overall rate of increase was 0.095/(10a). The vegetation index of Yan'an City changed dynamically from 2000 to 2019, showing an overall upward trend. Among

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them, 79.83% of the regional vegetation showed an improvement trend, mainly distributed in the loess beam and gully areas in the north and east of Yan'an City. Degraded areas accounted for 0.34% of Yan'an, mainly distributed in the suburbs of Yan'an urban and county-level cities, and distributed in dots and strips. The vegetation index of Yan'an City is affected by both natural factors and human activities. Among them, from 2000 to 2012, affected by the government's project of returning farmland to forest and grassland, NDVI increased rapidly. During this period, human activities were the dominant factor in determining the status of the vegetation index. From 2013 to 2019, the vegetation index of Yan'an City fluctuates greatly, and its trend curve is basically consistent with temperature and precipitation. The main factor affecting the growth of vegetation in Yan'an is water and heat conditions.

Acknowledgements

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