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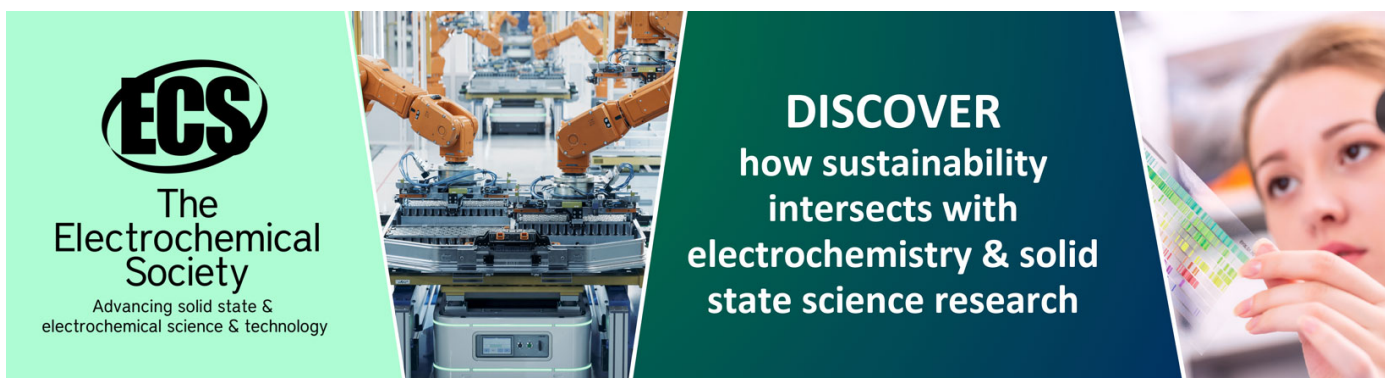
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Assessment of Vegetation Condition Change and Impacts of Human Activities in Guanzhong Plain During 2000-2015: A Case of Xianyang City

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Abstract. The agricultural production in Guanzhong Plain plays an important role in food security, ecological environment and socio-economic sustainable development in the Loess Plateau. Taking Xianyang City as an example, this paper analyzed the responses of vegetation condition to meteorological factors, particularly for crop growth period, and distinguished the contribution rate of climate and human activities for different periods. The results showed that the average slope of NDVI change trend in the vegetation area of Xianyang City was 0.005/year from 2000 to 2015. The northern part showed a significant growth trend of NDVI, while the south was mixed. NDVI in spring was significantly correlated with temperature and wind speed. The relative contribution rates of human activities to crop condition changes were 58.3%; NDVI during July-September was significantly correlated with wind speed and precipitation. The relative contribution rate of human activities reached 66.1%.

1. Introduction

The Loess Plateau is in the transition zone of semi-humid, semi-arid and arid regions. The fragile ecological environment is sensitive to environmental changes, and greatly restricted the economic development, especially agricultural production in plain. Due to the serious ecological problems, the Loess Plateau has been carrying out large-scale ecological engineering construction of returning farmland to forests and grasslands since 1990s. Most researches focused on the effects of ecological environment, but very limit on agricultural development.

Vegetation closely links soil, atmosphere and water on Earth. Vegetation index was a sensitive indicator to agricultural production, ecological environment and global change research [1-3]. Many researchers have studied the response of the Normalized Vegetation Index (NDVI) of the Loess Plateau to changes in temperature and precipitation [4-6]. In response to climate change in different dry and humid climates in the upper reaches of the Yellow River, NDVI in semi-humid areas increased significantly, and temperature was the main climatic constraint for vegetation growth; NDVI in semi-arid areas increased slightly and was sensitive to changes in precipitation [7]. Chen and Yuwen (2004) analyzed the grain yield changes and climatic factors in the Loess Plateau in the past 50 years (1949-1998), and found that the fluctuations of yield and precipitation were consistent in the



cycle (about 10 years), and climate volatility was the direct factor of crop yield and quality changes[8]. The study on the relationship between vegetation and precipitation and temperature in the Loess Plateau showed that the NDVI in the farmland area was positively correlated with the temperature in the same season. The correlation coefficient between spring, summer and winter is 0.51-0.567, and the lowest in autumn is 0.36 [9]. Zhang et al (2008) used statistical data to analyze the spatial and temporal characteristics of agricultural production efficiency in 281 counties (cities) of the Loess Plateau from 1987 to 2014, and found that the overall agricultural efficiency was moderate, but the regional differences are significant. The Guanzhong Plain as an important main grain producing area was at medium and high efficiency levels [10].

Remote sensing has advantages in the relations of vegetation and climate factors at regional scale. Most researches currently focus on ecological restoration or ecological environment effects. The researches on agriculture are still using the statistical data. Taking Xianyang City in the Guanzhong Plain as study area, this paper was aimed to use vegetation index from remote sensing to analyze the trend of vegetation condition and the impacts of climate factors and human activities on the vegetation condition index in crop land. The fully understanding the response of agriculture to climate conditions was helpful to counter with the problems of agricultural development. It also provides useful information for the sustainable development of agriculture in the Loess Plateau region with limited agricultural resources and ecological restoration construction.

2. Materials and Methodology

2.1. Study area

Xianyang City is located in the middle of Guanzhong Plain between 34.2°-35.6°N and 107.7°-109.2°E. The total land area is 10246km². The City belongs to the warm temperate semi-humid continental climate zone. The average annual precipitation is 562mm, concentrated in July-September. The annual average temperature is 9.0-13.2 °C. Xianyang is a commodity grain base, and its grain output ranks first in Shaanxi Province. According to the 2015 Statistical Yearbook, the grain output reached 1.924 million tons. The main grains are high-quality wheat and corn, with output of 1.0325 million tons and 0.8412 million tons respectively. Agricultural production has important practical significance for food security and social and economic development in the region.

2.2. Data

The EOS/MODIS MOD13 NDVI data products released by the National Aeronautics and Space Administration (NASA) was used in this study, with a time range of 2000-2015, a spatial resolution of 250 m and a time resolution of 16 days. The 16-year monthly NDVI data set of Xianyang City was obtained using the maximum synthesis method and the city boundary.

The daily meteorological grid data from 2000 to 2015 was obtained from the lab of digital agriculture in Institute of Remote Sensing and Digital Earth, CAS. This dataset were produced using meteorological data from 180 stations in the Loess Plateau. Here, we just obtained and processed to the monthly data for Xianyang City.

2.3. Methodology

Regression analysis is a mathematical statistical method that deals with the correlation between variables, and provides mathematical expressions of the correlation between variables. Multiple linear regression method is used to determine the quantitative relationship between the dependent variable and multiple independent variables. Its mathematical model is shown as formula (1) below:

$$y = a + b_1x_1 + b_2x_2 + \dots + b_nx_n \quad (1)$$

x is an independent variable, y is a dependent variable, b₁, b₂, b_n are pending parameters, and a is a constant, indicating the sum of the effects of random factors on y. In this paper, x is the meteorological element (temperature, precipitation, etc.), and y is NDVI. Considering the difference in crop growth phenology, the main seasons for spring and autumn crops growing season are March-May and July-

September, respectively. Therefore, the regression analysis of the relationship between NDVI and meteorological factors in the whole year and two growth periods were carried out. F-test was used to judge the significance for the linear regression equations.

3. Results and Discussion

3.1. Temporal changes of climate factors

For the five climate factors during 2000 to 2015 (annual average temperature, annual precipitation, total annual sunshine hours, annual average wind speed and annual average relative humidity), the linear trend analysis showed that only the change of sunshine hours in the past 16 years had a non-obvious downward trend. Temperature, wind speed and relative humidity all showed a significant downward trend, with annual decline rates of 0.09°C , 0.044 m/s and 0.44% , respectively. The average annual precipitation is 485 mm , and the annual precipitation showed a significant increase trend with an annual rate of increase of 7.93 mm . In general, Xianyang City has entered to the dry and cold phase in recent 16 years.

Considering the cycle of agricultural production, the main growth seasons of summer harvest and autumn harvest crops are March-May and from July-September. The average temperature, precipitation, sunshine hours, average wind speed and average relative humidity of the critical period from 2000 to 2015 are calculated. The wind speed and relative humidity showed significant decrease trends during March-May and July-September, and the annual decline rate was $0.045\text{--}0.047\text{ m/s}$ and $0.36\%\text{--}0.46\%$, respectively. The precipitation in the two seasons showed significant increase trends, and the annual increase rate was about 5.3 mm ; the temperature in March-May showed a significant downward trend with the annual decline rate of 1.04°C , and the increase trend from July to September with an increase rate of 0.45°C . Therefore, the agro-meteorological conditions after the winter crops return to green are mainly dry and cold in spring, while dry and hot for the autumn harvested crops.

3.2. Spatial and temporal changes of NDVI

For the 2000-2015 annual NDVI maximum, the linear fitting result at pixel scale was calculated. Fig.1 showed the change slope of the fitted line and the spatial distribution of the determination coefficient of the fitting equation. The slope reflects the trend and range of NDVI change. The positive slope indicated of increasing NDVI, otherwise decreasing trend.

The average slope of NDVI change in the vegetation area of Xianyang City was $0.005/\text{year}$, with the range of $-0.039\text{--}0.029$. The spatial variation of NDVI change in the city is significant, with increasing NDVI in most of the north region and decreasing trend in the south. The number of pixels passing the significance test ($\alpha=0.05$) accounted for about 52.2% of the vegetation area, of which 49.1% area with increasing trends mainly concentrated in the northern region, while the area with decreasing trend was only 3.1% . Over the past 16 years, 52.5% of the forest areas and 77.3% of the grass areas showed significant increase trends in NDVI, which may be related to the ecological construction of returning farmland to grassland. In about 38.9% of crop land, NDVI showed a significant growth trend and mainly distributed in the northern and central regions, while most of the southern farmland areas showed decreasing trends.

Xianyang City has a typical two cropping system. According to the main growing season of summer harvest and autumn harvest crops, the season NDVI dataset was calculated using the average synthesis method from March to May and July to September. In the past 16 years, the areas where cultivated land showed significant growth trends of NDVI change in spring and summer accounted for 39.0% and 32.7% , respectively. As shown in Fig.2, NDVI trends in the two seasons are generally similar. The NDVI change with decreasing trends was mainly concentrated in the south, while the northern part showed significant increase trends.

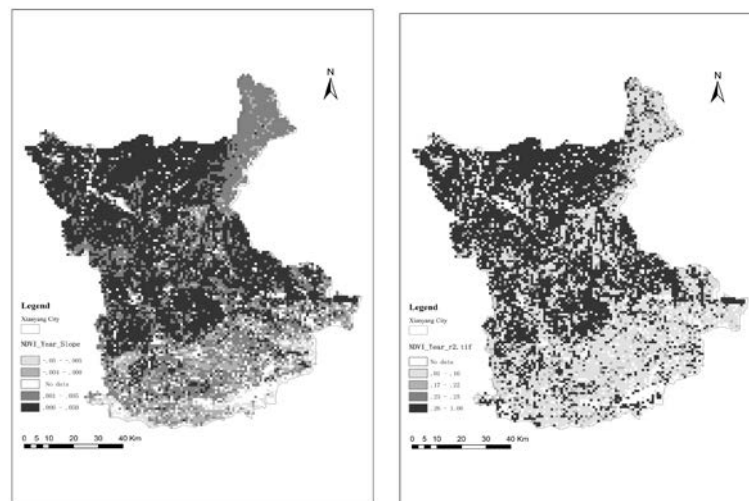


Figure. 1. The slope (left) and determination coefficient (right) map of monthly maximum NDVI change during 2000-2015.

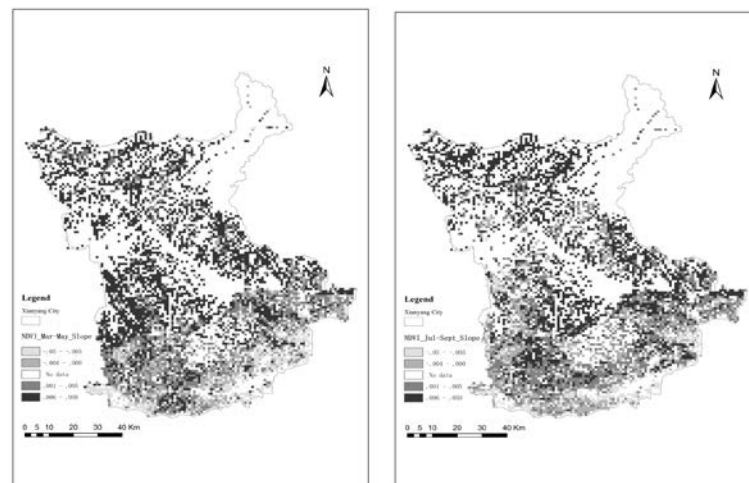


Figure. 2. The slope maps of seasonal NDVI change for two growth period of March-May(left) and July-September(right) during 2000-2015.

3.3. Impact analysis of climate and human activity on crop condition

Correlation analysis between vegetation index and climatic factors showed that except for sunshine hours, the correlation coefficients between NDVI and annual average temperature, annual precipitation, annual mean wind speed and annual average relative humidity were -0.43, 0.54, -0.78 and -0.49, respectively. The annual precipitation was significantly positively correlated with the vegetation growth. The increase of precipitation promotes the vegetation growth to a certain extent.

From March to May, vegetation NDVI was significantly correlated with temperature ($r=-0.73$) and wind speed ($r=-0.51$), and positively correlated with precipitation ($r=0.45$), and was not correlated with sunshine hours and relative humidity. The proportion of cultivated land with negative correlation between NDVI and temperature and wind speed was 93% and 71%, respectively, of which significant negative correlations accounted for 25% and 42%, respectively; NDVI was positively correlated with precipitation with the proportion of 76%, and significant positive pixels accounted for 42%. From July to September NDVI was significantly correlated with wind speed ($r=-0.68$), and precipitation ($r=0.62$), and was not correlated with temperature, sunshine hours and relative humidity. The proportion of cultivated land with positive correlation between NDVI and precipitation was 91%, of which the

positively correlated positive pixels accounted for 29%; while the proportion of negatively correlated with the wind speed was 85% and significant related pixels accounted for 43%.

According to the above correlation analysis, the precipitation, temperature, wind speed are selected as independent variables, and NDVI is used as the dependent variable, and then the coefficients were determined by the multi-linear regression model. The contribution rate of human activities was calculated based on the difference between the simulated NDVI and the NDVI. From March to May, the relative contribution rate of human activities to NDVI changes was 58.3%, and the relative contribution rate of climate to NDVI changes was 42.7%. The relative contribution rates of climate and human activities to NDVI changes from July to September were 34.9% and 66.1%, respectively.

4. Conclusions

The agricultural development of Xianyang City has an important practical significance for food security and ecological environment of the Guanzhong Plain and even the entire Loess Plateau. In this paper, the vegetation index NDVI and meteorological data during 2000-2015 were used to analyze the spatial and temporal trends of crop condition, especially the two main growth seasons. The following conclusions were drawn:

(1) The slope of NDVI change in the vegetation area of Xianyang City is 0.005/year with the range of -0.039~0.029. The north was dominated by increasing trends, and the south was more complex. NDVI in 52.5% of the forest area and 77.3% of grass area showed significant increase trends, but only about 38.9% for the cultivated area. It also implied of the remarkable effects of ecological construction engineering in the Loess Plateau since 1990s.

(2) In the past 16 years, NDVI change in cultivated land for two main growth seasons was generally consistent; however, the sensitive meteorological factors were different. NDVI had a significant positive correlation with temperature and wind speed during March-May; For July-September, NDVI was significantly negatively correlated with wind speed, and positively with precipitation. The different sensitive meteorological factors for different periods need be paid more attention on the agricultural production practice.

(3) Human activities had more impacts on crop condition change in the city in recent 16 years. The relative contribution rates of climate and human activities to NDVI changes for March-May were 42.7% and 58.3%, respectively, and for July-September were 34.9% and 66.1%, respectively.

5. Acknowledgments

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6. References

- [1] Gao, Z.Q., Liu, J.Y.: The study on driving factors and models of NDVI change based on remote sensing and GIS in China. *Climatic and Environmental Research*. 5(2): 155-164 (2000).
- [2] Foody, G.M.: Geographical weighting as a further refinement to regression modelling: An example focused on the NDVI-rainfall relationship. *Remote Sensing of Environment*. 88(3): 283-293 (2003).
- [3] Wang, Z., Liu, S.R., Zhou, L.D., et al.: The relationship of vegetation greenness period and climate precipitation change in the north-south transect of eastern China. *Procedia Environmental Sciences*. 10(1): 282-288 (2011).
- [4] Guo, N., Zhu, Y.J., Wang, J.M., et al.: The relationship between NDVI and climate elements for 22 years in different vegetation areas of northwest China. *Journal of Plant Ecology*. 32(2): 319-327(2011).
- [5] Chen, A., Sun, L., Hu, B., et al.: Changes of NDVI and its responses to temperature and precipitation on Loess Plateau over last ten years. *Bulletin of Soil and Water Conservation*. 31(5): 215-219 (2011).
- [6] Li, S.S., Yan, J.P., Wan, J.: The spatial-temporal changes of vegetation restoration on Loess Plateau in ShaanxiGansu-Ningxia region. *Acta Geographica Sinica*, 67(7): 960-970 (2012).

- [7] Du, J.Q., Shu, J. M., Zhang, L.B., et al.: Responses of vegetation to climate change in the headwaters of China's Yellow River Basin based on zoning of dry and wet climate. *Chinese Journal of Plant Ecology*, 35(11):1192-1201(2011).
- [8] Chen, X.N., Yuwen, G.F.: Effect on the sustainable development of agriculture by Guanzhong climate resources. *Journal of Xianyang Teacher's College*. 19(2): 44-47(2004).
- [9] Xie, B. N.: Vegetation dynamics and climate change on the loss plateau, China: 1982-2014. Xianyang: Doctoral Dissertation of Northwest Agriculture and Forest University (2016).
- [10] Zhang, P. P., Wang, F., Wang, L. Q., et al.: Spatio-temporal change of agricultural production efficiency in the loess plateau. *Agricultural Research in the Arid Areas*. 36(3):218-225 (2018).