

Analysis on Temporal and Spatial Pattern Change and Driving Force of Land Use in Agro Pastoral Ecotone in Northern Shanxi

Wenchao Liu¹, Mei Liu^{2,*}, Wenhui Jia¹, Xiaoyi Miao¹ and Meihong Ma¹

¹Tianjin Normal University, School of geography and environmental sciences, 300387 TianJin, China

²Tianjin Chengjian University, School of economics and management, 300384 TianJin, China

Abstract. Land use change is a considerable representation of mutual effect between human and natural activities. Northern Shanxi is located in the northern agro pastoral ecotone, which the land use pattern changes violently. This paper focuses on the dynamic change characteristics of cultivated land and grassland in the agro pastoral ecotone of northern Shanxi from 2000 to 2015, and explores the main driving factors of their change. It can provide support for land planning and management and relevant policy-making in northern Shanxi and promote regional sustainable development. The results showed that: ① There was a close interrelation between the change of cultivated land and grassland in northern Shanxi, and the whole showed the opposite dynamic change trend. ②The main land transfer type of cultivated land and grassland is construction land. And grassland is also the main transfer type of cultivated land. And cultivated land contributes greatly to the growth of grassland area. ③Economic factors are the main driving force which affecting the area change of cultivated land and grassland, followed by the benefit factors of agricultural development, and finally the labor factors. ④Economic factors can explain the shift of cultivated land and grassland in different districts and counties in northern Shanxi. The benefit factor of cultivated land development plays a negative driving role on cultivated land, the benefit of grassland development plays a promoting role on the growth of grassland area, and the driving force of labor factor is relatively small.

1 Introduction

Land use change can directly reflect the results of the interaction between human and natural activities. It is an important research topic related to environmental change and sustainable development. Northern Shanxi is located in the northern agro pastoral ecotone. The natural environment is fragile and transitional, and it is the key construction area of ecological engineering. The land use situation is special and complex, and the land use pattern changes violently.

Among the global environmental change issues, land use change is the most closely issue of the intersection of natural and humanistic processes. Since 1990, the research field of global environmental change has gradually strengthened the research on Land Use and Land Cover Change (LUCC), mainly focusing on the process, driving force and eco-environmental effect of land use change[1]. The international community mainly focuses on the relationship between land use change and global environmental change and sustainable development, focusing on the research on the driving mechanism of global and intercontinental macro-scale land use change and eco-environmental effects, especially the impact on climate change and gas emissions[2]. Relevant research scales in China are relatively wide, it is involved from the macro national scale to provinces, cities and counties[3]. The Loess Plateau, the Yellow River Basin [4] and the ecotone

between agriculture and animal husbandry[4] are the research hotspots. Research methods are mostly based on 3S technology to analyze the magnitude, speed and regional differences of quantitative change of land use types in different research areas, and then explore the main types, distribution characteristics and regional direction of land use spatial change[6]. The driving force research mostly adopts mathematical statistical methods such as principal component analysis and regression analysis[7]. The driving force factors, including socio-economic driving force, natural driving force and land use policy driving force.

The ecological environment in northern Shanxi is fragile and the contradiction between man and land is prominent. Based on the typical characteristics of farming pastoral ecotone in northern Shanxi and RS and GIS technology, this paper focuses on the change characteristics and driving forces of two representative land use types of cultivated land and grassland in the study area from 2000 to 2015. This study helps to ensure the sustainable development of the region, so does to help land planning and management and the formulation of relevant policies.

* Corresponding author: hebeilumei@126.com

2 Overview of the study area and data sources

2.1 Overview of the study area

Northern Shanxi is located in the north of Shanxi Province, including Datong City, Shuozhou City and Xinzhou City. Northern Shanxi has complex and changeable landform, widely distributed loess, poor ecological environment and infrastructure. And the development of social economy lags behind. Although coal mine related industries are developed, the intensity of air pollution and environmental damage is great. Since 2000, the study area has taken a series of major measures to actively control the ecological environment, and the quality of the ecological environment has been improved. However, due to the great natural conditions and man-made pressure, there are still common environmental problems such as land desertification and sparse vegetation.

2.2 Data source and processing

The basic data in this paper are mainly the land use data and socio-economic data in 2000, 2005, 2010 and 2015. The land use data comes from the "national land use 1:100000 database" provided by the Chinese Academy of Sciences. The Landsat remote sensing image and Google Earth image are used for data processing, and finally the land use data with an accuracy of more than 95% is obtained. The process and spatial pattern of land use change in each county in the study area are obtained through ArcGIS spatial processing. The economic and social statistical data comes from China county statistical yearbook, and used SPSS to standardize the data and PCA principal component analysis to obtain the main socio-economic driving forces of land use pattern change in northern Shanxi, and then explore the driving forces of different principal components.

3 Analysis of temporal and spatial pattern change characteristics of land use

3.1 Temporal and spatial trajectory analysis of land use change

The farming and pastoral areas are distributed in a zonal crisscross manner, roughly from southwest to northeast. Moreover, most of the cultivated land is concentrated in the abdomen of the study area, while the grassland is distributed in the marginal area (Fig.1), which is related to the mountainous terrain in northern Shanxi and also reflects its obvious characteristics of farming and pastoral crisscross zone.

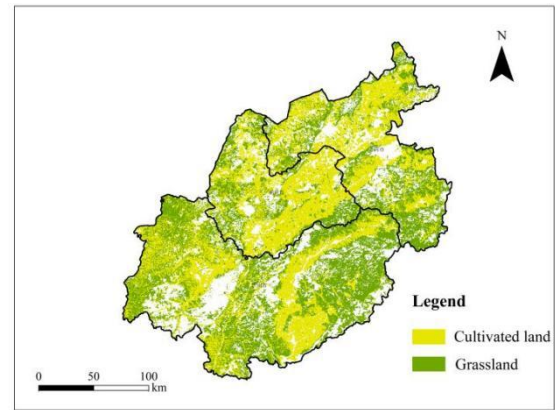


Fig. 1. Distribution of land use status in Northern Shanxi in 2015

It is found that the cultivated land area in the study area generally showed a decreasing trend from 2000 to 2015 (Table 1), and the change was the most drastic from 2005 to 2010, with a decrease of 1.76% compared with the original area. By analyzing the trajectory of land use change through the transfer matrix, it can be seen that grassland and construction land contributed the most to the reduction of cultivated land area from 2000 to 2005, forest land and construction land from 2005 to 2010 and construction land from 2010 to 2015. It is found that the cultivated land occupied by construction land has been serious, and the implementation effect of ecological conversion of farmland and conversion of farmland to forest from 2000 to 2010 is remarkable. From 2000 to 2015, the grassland area in the study area increased first and then decreased, and increased significantly from 2000 to 2005, an increase of 0.84% compared with the initial area. From 2000 to 2010, cultivated land contributed the most to the growth of grassland area, far exceeding the area converted from grassland to cultivated land. After 2010, the area of grassland converted to cultivated land has increased significantly, the area of cultivated land and grassland transferred to each other is equivalent, and the area of grassland converted to construction land has more than doubled compared with before.

Overall, the change degree of cultivated land is more intense than that of grassland, and the change trend is roughly opposite. From 2000 to 2010, the policy of returning farmland to forest had an obvious effect on the area change of cultivated land, grassland and forest land. The cultivated land showed a decreasing trend. A large number of cultivated land was converted to grassland and forest land, while the grassland was in a fluctuating and increasing trend. After 2010, the decreasing trend of cultivated land area slowed down significantly, and the trend of cultivated land turning into grassland and forest land decreased significantly, while the grassland area showed a decreasing trend after 2010, but the change range was small, only 0.18% less than the initial area. Construction land has always been the main transfer type of cultivated land and grassland, which is related to the massive mining of coal, the continuous

development and construction of cities and towns and the improvement of urbanization level in northern Shanxi.

the dynamic degree of cultivated land and grassland is low.

Table 1. Statistics of Land Use Type Change

Time period (year)	2000-2005		2005-2010		2010-2015	
Land use type	Cultivated land	Grassland	Cultivated land	Grassland	Cultivated land	Grassland
Area change (%)	-1.33	0.84	-1.76	0.04	-0.36	-0.18

3.2 Spatial dynamic analysis of land use change

According to the dynamic degree calculation, the cultivated land area of most counties and districts in northern Shanxi showed a decreasing trend from 2000 to 2015, among which the absolute value of the dynamic degree of cultivated land change in the mining area and urban area of Datong City was the largest. The urban construction in these two districts developed rapidly, resulting in the fastest reduction of cultivated land. The dynamic degree of cultivated land change in the Southern suburb and Pinglu district is relatively low, which are -1.095% and -0.827% respectively. Both districts are important coal producing counties. Many cultivated land has been converted to industrial and mining land and workers' living areas, while the agricultural development is poor, resulting in the relatively rapid reduction of cultivated land. Ying county has the highest dynamic degree of cultivated land change, which is 0.069%. Its agricultural development conditions are good, which is conducive to cultivated land reclamation. Among the 31 counties, there are 15 positive and 16 negative grassland change dynamics. From the number of counties, the grassland area increases and decreases, and the number of counties increases and decreases is the same. In terms of change degree, Kelan county has the largest grassland change dynamic degree, which is 1.00%, far higher than other counties and regions. The grassland change dynamic degree of Guangling, Hequ, Pinglu, Shanyin, Wuzhai and Youyu counties is relatively high, all around 0.20%. The county dynamic degree of grassland area with negative trend change is generally low, and the absolute value of change dynamic degree is within 0.17%.

By comparing the spatial distribution of the area change dynamics of cultivated land and grassland, it can be seen that the utilization changes of cultivated land and grassland in northern Shanxi are closely related, showing the opposite dynamic change trend as a whole. The counties with high Grassland Change Dynamics generally have good animal husbandry development, while the spatial dynamic changes of cultivated land change dynamics are greatly affected by mineral resources (Fig.2). The dynamic degree of cultivated land change in Pinglu district and Kelan county is low, and the grassland is relatively high; the area of cultivated land and grassland in Guangling County, Pianguan County, Baode County and Wutai County also showed the opposite dynamic change trend; several counties in the urban area, mining area and southern suburb of Datong are special, and

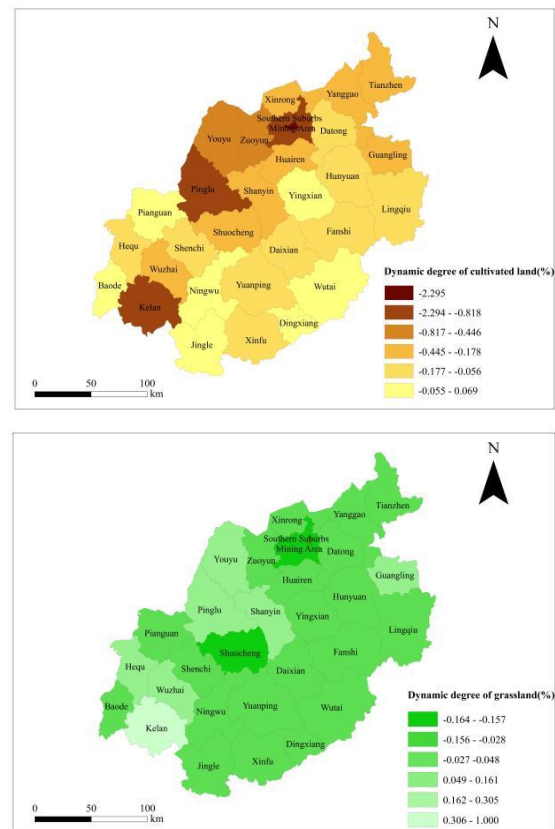


Fig. 2. Spatial distribution of dynamic degree of cultivated land and grassland Change

4 Analysis on driving forces of land use change

According to the existing analysis, natural factors and relevant policies are the main factors leading to the change of cultivated land and grassland in the agro-pastoral ecotone in northern Shanxi. This paper uses the principal component analysis method to comprehensively analyze the socio-economic factors and explore the main driving forces affecting the change of cultivated land and grassland in the region.

4.1 Determine the driving force index and driving force principal component

The influencing factors of land use and cover change include natural factors and socio-economic factors, among which the socio-economic driving force plays a strong role. This paper makes a principal component analysis on 103 samples from 29 counties and 4 years in northern Shanxi. The total population, agricultural population, regional GDP, primary industry output value, secondary industry output value, tertiary industry output value, agricultural output value, animal husbandry output value, forestry output value, main grain output, total meat output, total power of agricultural mechanization, industrial sales output

value, total retail sales of social consumer goods The general budget expenditure and the number of people engaged in agriculture are 16 socio-economic indicators, and the kmo test value of the correlation matrix is 0.794, which is suitable for principal component analysis. Three principal components are extracted from the 16 indicators. The first principal component (F1) economic factor, the second principal component (F2) agricultural development benefit factor and the third principal component (F3) labor force factor are the main driving factors of cultivated land use change. The contribution rates are 55.962%, 17.374% and 9.469% respectively, and the cumulative contribution rate reaches 82.805%, which can represent the social and economic development of northern Shanxi.

4.2 Analysis on driving forces of land use pattern

4.2.1 Quantitative analysis of driving force

In order to clearly judge the driving effect of each principal component on the change of cultivated land and grassland utilization in northern Shanxi, the extracted principal components were quantitatively calculated. According to the factor score coefficient, combined with the standardized value of each influencing factor, the principal component scores of driving force of each district and county in northern Shanxi in different years are calculated. The analysis shows that in 2000, the third principal component of the driving force, the labor force factor, was the main driving force for the change of cultivated land use at that time, but since 2010, the first principal component and the second principal component have gradually developed into the main socio-economic driving force (Fig.3).

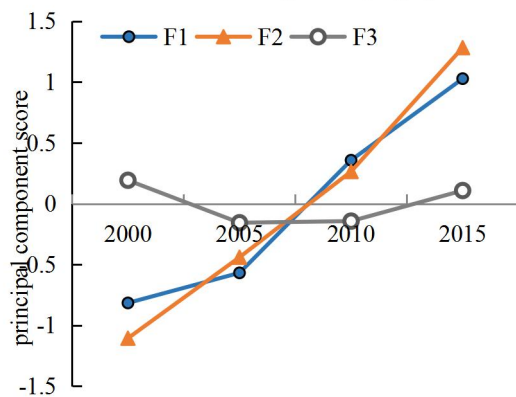


Fig. 3. Statistical chart of principal component scores from 2000 to 2015

4.2.2 Principal component analysis of driving force

(1) Economic factors

From 2000 to 2015, the first principal component scores of districts and counties in northern Shanxi showed an upward trend year by year. In 2000, the overall scores of districts and counties were low, but with the increase of years, the score gap of economic factors between regions was significantly widened, among which Shanyin County, Huairan County and Hequ County were several counties with rapid increase in economic factor scores. The

abundance of coal resources in northern Shanxi determines the driving force direction of economic factors to a great extent. For districts and counties that rely on coal to develop economy, represented by Yuanping City, mainly rely on the development of industry to drive economic growth, and economic factors play a negative driving role in the increase of cultivated land and grassland. for Youyu County, Wuzhai County and Kelan County, represented by Shanyin County, which lack coal resources and focus on the development of animal husbandry economy, economic factors play a role in promoting the grassland area and a negative driving force on the cultivated land area.

(2) Benefit factors of agricultural development

From 2000 to 2015, the overall agricultural output value and animal husbandry output value in northern Shanxi showed an upward trend, and the agricultural output value was higher than the animal husbandry output value. While the score of agricultural development benefit factors is rising, the cultivated land area in northern Shanxi is greatly decreasing, while the grassland area is increasing. It can be seen that although the area of cultivated land has decreased, its output value is increasing. It shows that with the improvement of agricultural science and technology level, the output benefit per unit of cultivated land is also increasing. Therefore, the benefit factors of cultivated land development play a negative driving role in the increase of cultivated land. At the same time, for the districts and counties with developed animal husbandry, the benefit of developing animal husbandry is higher than that of developing agriculture, so as to promote the transfer of cultivated land to grassland and accelerate the reduction of cultivated land and the increase of grassland. Therefore, the benefit factors of grassland development play a promoting role in grassland area and a negative driving role in cultivated land area.

(3) Labor factor

From 2000 to 2005, the urbanization rate in northern Shanxi developed rapidly, a large number of rural population transferred to urban life and employment, and the number of agricultural labor force decreased to a certain extent. From 2005 to 2015, the number of agricultural labor force increased from 10246 million to 11624 million, and the decline of cultivated land area decreased significantly from 2010 to 2015. The increase of rural labor force engaged in agriculture has played a certain role in promoting the increase of cultivated land. The labor force factor plays a positive driving role in the area of cultivated land, while it plays a negative driving role in the increase of grassland area. The increase of population will drive the growth of food demand, and then attract labor force to engage in agriculture, plough a pile of wasteland or reclaim new cultivated land, promote the increase of cultivated land, but also promote the transfer of grassland to cultivated land.

5 Conclusion

Firstly, this paper studies the land use change pattern and its socio-economic driving forces in the agro pastoral ecotone in northern Shanxi from 2000 to 2015, and draws the following main conclusions:

(1) From the time dimension, the cultivated land and grassland showed the opposite trend around 2010. From 2000 to 2010, the cultivated land in northern Shanxi decreased rapidly, which was mainly transformed into construction land and grassland, and the grassland area showed an increasing trend. The main source of increase was cultivated land. From 2010 to 2015, the reduction rate of cultivated land area decreased significantly, and the grassland area began to decrease. Labor factors and cultivated land protection policies are the main driving forces for the change of cultivated grassland.

(2) From the perspective of county spatial dimension, the distribution of coal resources and animal husbandry development conditions in the county of northern Shanxi Province largely determine the driving direction of economic factors, and then affect the spatial change dynamics of cultivated land and grassland. For districts and counties that rely on coal to develop economy, economic factors play a negative driving role in the growth of cultivated grassland area. For districts and counties that develop animal husbandry, economic factors promote the growth of grassland area and play a negative driving role in the growth of cultivated land.

(3) On the whole, firstly, the policy of returning farmland to forest and grassland directly induced the reduction of cultivated land and the increase of grassland in northern Shanxi. The cultivated land protection implemented later slowed down the reduction rate of cultivated land and indirectly led to the reduction of grassland. Secondly, the driving effect of socio-economic driving force on the change of cultivated grassland is more intense, in which economic factor is the main driving force, followed by the benefit factor of agricultural development,

and finally the labor factor.

Funding

This work was supported by Deep learning-based research on the inducing factors and early warning of flash floods (42101086).

References

1. H Zhao, He H, Bai C, et al. Characteristics of land use change and its environmental effects on the Loess Plateau. *China land science*. **(07)**: 51-59 (2018).
2. Watson R T, Noble I R, Bolin B, et al. *Land Use, Land Use Change, and Forestry: a Special Report of the IPCC* (2000).
3. J Wang, L Chen, Y Wang . Review on the evolution of landscape pattern in the Loess Plateau. *Progress in geographical science*. **29 (05)**: 535-542 (2010).
4. Y Luo, S Yang, X Liu, et al. Characteristics of land use change in Hekou town Tongguan section of the Yellow River from 1998 to 2010. *Journal of geography*. **(01)**: 44-55 (2014).
5. S Yang, H Yan, L Guo . Land use change and its eco-environmental effects in the northern agro pastoral ecotone -- a case study of Yulin City, Northern Shaanxi. *Progress of geographical science*. **(06)**: 49-55 (2004).
6. H Zhu, X Li, S He, et al. Analysis of temporal and spatial changes of land use around the Bohai Sea. *Journal of geography*. **(03)**: 253-260 (2001).
7. J Liu, W Kuang, et al. Basic characteristics and spatial pattern of land use change in China since the late 1980s. *Journal of geography*. **69 (01)**: 3-14 (2014).