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Effects of rural–urban migration on vegetation greenness in fragile areas:
A case study of Inner Mongolia in China

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Abstract: Different government departments and researchers have paid considerable attention at various levels to improving the eco-environment in ecologically fragile areas. Over the past decade, large numbers of people have emigrated from rural areas as a result of the rapid urbanization in Chinese society. The question then remains: to what extent does this migration affect the regional vegetation greenness in the areas that people have moved from? Based on normalized difference vegetation index (NDVI) data with a resolution of 1 km, as well as meteorological data and socio-economic data from 2000 to 2010 in Inner Mongolia, the spatio-temporal variation of vegetation greenness in the study area was analyzed via trend analysis and significance test methods. The contributions of human activities and natural factors to the variation of vegetation conditions during this period were also quantitatively tested and verified, using a multi-regression analysis method. We found that: (1) the vegetation greenness of the study area increased by 10.1% during 2000–2010. More than 28% of the vegetation greenness increased significantly, and only about 2% decreased evidently during the study period. (2) The area with significant degradation showed a banded distribution at the northern edge of the agro-pastoral ecotone in central Inner Mongolia. This indicates that the eco-environment is still fragile in this area, which should be paid close attention. The area where vegetation greenness significantly improved showed a concentrated distribution in the southeast and west of Inner Mongolia. (3) The effect of agricultural labor on vegetation greenness exceeded those due to natural factors (i.e. precipitation and temperature). The emigration of agricultural labor improved the regional vegetation greenness significantly.

Keywords: rural-urban migration; agricultural labor; vegetation greenness; NDVI; Inner Mongolia

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1 Introduction

Human activities are influencing the global environment in many ways, with numerous direct and indirect effects on a variety of ecosystems. Currently, rural–urban migration is the most significant human activity, especially for developing countries like China. The rural population of China reduced by 17.0% between 2000 and 2010, based on the demographic census. This migration could well continue for a long time to come, accompanied by further rapid industrialization and urbanization. It is interesting to speculate that this process may have promoted the greenness of terrestrial vegetation in ecologically fragile areas. Studies have indicated that changes in population and environmental impact maintained proportionately similar trends (Xu and Cheng, 2005).

Vegetation index has a positive linear relationship with vegetation cover in areas with low vegetation coverage rates (Liu and Gong, 2012; Watinee and Netnapid, 2013; Fu and Burgher, 2015; Li *et al*., 2015; Liu *et al*., 2015; Rao *et al*., 2015; Xu *et al*., 2015). Thus it can be used to investigate the changes in regional vegetation cover. The normalized difference vegetation index (NDVI), one of several vegetation indexes, has been widely used to study vegetation changes at different scales (Fan *et al*., 2012; Chuai *et al*., 2013; Rodrigues *et al*., 2013; Zhang *et al*., 2013; Yi *et al*., 2014; Zhang *et al*., 2014; Tan and Li, 2015). For convenient comparison with existing research results, in this study we used NDVI to measure vegetation changes.

The Inner Mongolia Autonomous Region is located on the northern frontier of China (Liu *et al*., 2015), which belongs to the transition zone from arid and semi-arid climate of the northwestern inland areas to the humid and semi-humid monsoon climate of the southeastern coast. This region is the most important agricultural and animal husbandry production base in China, where the intensity of human activity is high and the eco-environment is fragile (Mu *et al*., 2012). Recently, with the increasing prominence of environmental and climate issues, Inner Mongolia, which controls the areas of wind and sand sources in Beijing and Tianjin, has been greatly concerned about changes in the eco-environment and the factors that might affect it. The effects of natural factors on the distribution and growth of vegetation cover have been analyzed in previous studies. The timescales of these studies varied from monthly to inter-annual scales, and the spatial scales varied from pixel to regional scales (Sun *et al*., 2010; Wang *et al*., 2012; Chuai *et al*., 2013; Zhang *et al*., 2013; Hilker *et al*., 2014; Li *et al*., 2015). Mu *et al.* (2012), amongst others, analyzed the response of the vegetation dynamic changes to climate change on different timescales, including monthly and annual scales, analyzed at both regional and overall spatial scales, dividing the land area into ecological forest areas, grassland ecological areas and desert ecological areas. Additionally, Wang investigated the inter-annual variation in vegetation and its relationship to temperature and precipitation, and thereby estimated the contribution rates for these factors in central Inner Mongolia within a radius of 1 km of meteorological stations (Wang *et al*., 2012).

Recently, human–environment interactions have experienced dramatic changes due to population migration. Census data show that the number of permanent residents has increased by 950,000, an increase of 4%, while the number of rural residents has decreased by 2.37 million, a decline of 17.8%, above the national average, and which was 17% in the autonomous region between 2000 and 2010. The changes in human–environment interaction ought to have a great impact on the eco-environment. Therefore, the impact of human activities on the regional vegetation has increasingly attracted greater attention (Sun *et al.*, 2010; Wang *et al.*, 2012; Wu *et al.*, 2013; Zhou *et al.*, 2014; Li *et al.*, 2015; Liu *et al.*, 2015). In particular, the correlations between vegetation greenness and temperature, and with precipitation in the study area were analyzed by means of NDVI and meteorological data. Then, on this basis, the impact of human activities on vegetation was studied via a residual analysis method (Sun *et al.*, 2010; Li *et al.*, 2011; Wang *et al.*, 2012; Li *et al.*, 2015).

Some scholars have divided human activities into different parts and analyzed their relationship with vegetation change individually. Xin studied the effects of human factors from the aspects of land use, agricultural production and vegetation construction (Xin *et al.*, 2008). Previous studies have mostly focused on the semi-quantitative analysis of human activities, taken as a whole, or a separate analysis of the pairwise correlation between certain factors and vegetation changes.

A large number of people have migrated out of these rural areas, especially the working-age population. Undoubtedly, the outward migration of rural labor will have an effect on the vegetation greenness of these areas. The question then arises: how will the migration of rural labor affect the vegetation greenness in the context of changes in natural environmental factors, especially precipitation and temperature? How to estimate the contributions of human activities to the vegetation conditions? These questions, and others, are addressed and discussed in this paper, which may not only help in understanding the mechanism of vegetation changes, but also have some reference value for the development of national and regional land use policies, environment restoration and management in fragile areas, and the reasonable guidance of rural–urban migration.

2 Data and methods

2.1 Dataset and preprocessing

This study used remote-sensing data, ground meteorological data and economic data. Ground meteorological data and economic data were used to investigate the driving forces causing changes in vegetation greenness.

Remotely sensed NDVI data: NDVI data with a 1 km×1 km spatial resolution, covering the period from May 2000 to October 2010, were downloaded from the GSCLOUD, Computer Network Information Center, Chinese Academy of Sciences (http://www.gscloud.cn/). In northern China, the vegetation growing season lasts from May to October, so these months are chosen to calculate annual mean NDVI values (Xu *et al.*, 2006). Then the average growing season NDVI (AGSNDVI) dataset from 2000 to 2010 at 1 km resolution was obtained for Inner Mongolia.

Climatic data from ground meteorological stations: Meteorological data for the years 2000 to 2010, including monthly mean temperature (MMT) and monthly total precipitation (MTP), were downloaded from the China Meteorological Data Sharing Service System (http://cdc.nmic.cn). The datasets, with 0.5°×0.5° grid-cell size, were acquired by the Thin Plate Spline (TPS) interpolation method from about 2400 meteorological stations in China. To produce raster images with the same temporal and spatial resolution as the NDVI remote-sensing images, an interpolation method was adopted for temperature and precipitation data. In this study, we used the same interpolation method with the original data, taking a 1 km digital elevation model (DEM) as additional covariates during the interpolation. Then the annual mean temperature (AMT) and annual total precipitation (ATP) datasets for the years 2000 to 2010 at 1 km resolution were acquired for Inner Mongolia. The climatic and remote-sensing images were all projected to the Krasovsky_1940_Albers geographic projection.

Socio-economic data: The statistical data at county level, including the rural agricultural labor force, total sown area, cultivated area and the number of livestock at the end of each year by species, were acquired from the National Bureau of Statistics for the years 2000 to 2010, amongst which the population and labor force data were gathered from the fifth and sixth national censuses. Out of concern for the integrity and consistency between population and agricultural statistics, the county-level administrative regions in 2000 were taken as standards, omitting city areas, planning solo cities and counties missing data in Inner Mongolia. Thus, 60 counties were regarded as study samples. To measure the pressure of human activities on land resources, the variable of livestock was selected, which was converted by species into sheep units (Wang and Gao, 2012).

2.2 Trend analysis of variables

Due to the contingency and volatility of changes in vegetation greenness and climatic factors during the study period, and the inevitable randomness of time division (Lu *et al*., 2011), we employed a trend analysis method to investigate the trend in NDVI and climatic factors between 2000 and 2010. Simple linear regression analysis simulated the tendency of each grid as follows:

$$SLOPE = \frac{n\sum_{i=1}^{n} ix_i - \sum_{i=1}^{n} i \sum_{i=1}^{n} x_i}{n\sum_{i=1}^{n} i^2 - (\sum_{i=1}^{n} i)^2} \tag{1}$$

where n is the number of years studied; X_i is the variable of year i, which could be AGSNDVI, AMT or ATP; and *SLOPE* is the slope of the trend line. $SLOPE > 0$ means that the changing tendency of the variable amongst n years is increasing, while $SLOPE < 0$ means that it is decreasing. With the help of ArcGIS software, the trends in variable data were collected at the county level for Inner Mongolia.

To check the validity of the regression model, a significance test was applied (Wang *et al*., 2010). Using the correlation coefficient R between the NDVI sequence and the time series, the magnitude and nature of changes in vegetation greenness can be evaluated. The critical values are 0.553 and 0.684 under the significant levels of 0.05 and 0.01, respectively, checked from the corresponding tables. According to the critical values, the variation trend was classified into five categories: extremely significant decrease (ESD, $SLOPE < 0$, $P < 0.01$); significant decrease (SD, $SLOPE<0$, $0.01<P<0.05$); no significant change (NSC, $P > 0.05$); significant increase (SI, $SLOPE>0$, $0.01<P<0.05$); extremely significant increase (ESI, $SLOPE >0$, $P<0.01$) (Mu *et al*., 2013).

2.3 Factor analysis and theoretical hypothesis

The factors were selected from the point of view of both natural factors and human activities

(Table 1). For natural factors, considering the response of vegetation to climate change that may have delayed effects (Wu *et al.*, 2009), we chose the changing trends of AMT and ATP during the study period as research indicators. As to human activities, gross population and its structure and land resource occupation per capita were considered in this study. The quantity of agricultural labor (QAL) was chosen to represent the pressure of population and the average age of agricultural labor (AAL) was chosen to represent the demographic structure. In considering the vegetation type, mainly dominated by meadow and arable land in Inner Mongolia, the stocking capacity per capita by the agricultural labor force (SCPAL) and the cultivated area per capita by the agricultural labor force (CAPAL) were used to measure the effects of production capacity per labor force on the regional ecosystem.

Table 1 Main factors impacting the changes in vegetation in Inner Mongolia

Category	Indicator	Variable	Description
Natural factors	ATP[a]	Slope ATP	Variation in trend of ATP for 2000–2010
	AMT[b]	Slope AMP	Variation in trend of AMT for 2000–2010
Human activities	QAL[c]	CRQAL	Rate of change of QAL for 2000–2010
	AAL[d]	CRAAL	Rate of change of AAL for 2000–2010
	CAPAL[e]	CRCAPAL	Rate of change of CAPAL for 2000–2010
	SCPAL[f]	CRSCPAL	Rate of change of SCPAL for 2000–2010

[a] ATP = total precipitation. [b] AMT = annual mean temperature.
[c] QAL = quantity of agricultural labor force. [d] AAL = average age of agricultural labor force.
[e] CAPAL = cultivated area per capita by agricultural labor force.[f] SCPAL = stocking capacity per capita by agricultural labor force.

Theoretically, rural–urban migration should relieve the ecological pressure on these rural areas, when changes in natural environmental factors under certain conditions, especially those of precipitation and temperature, promote an improvement in vegetation greenness. On the other hand, the activity intensity of the labor force and the change in regional vegetation greenness are in the opposite direction. This means, with either the scale of arable land management per capita or the number of feeding livestock per capita increasing, that pressure on the local ecosystem will increase and the vegetation greenness should degrade, in theory at least. In addition, the AAL should affect the activity of the labor force, thus having an impact on the vegetation greenness. This paper will set out to verify this hypothesis.

Inner Mongolia covers a vast geographic area, with a large span from east to west. There are great differences in size, natural environmental conditions and levels of socio-economic development amongst these counties. For example, in desert area of Alashan and Hexi Corridor, which are limited by natural conditions, the vegetation greenness is much lower than in other counties. To eliminate the background effects, we took the rate of change of human activities as variables in this study. A multiple linear regression method was used to investigate the relationship between changes in greenness and human activities and natural factors.

3 Results and discussion

3.1 Spatial distribution of the NDVI in the base year

Figure 1 displays the gradually decreasing trend in the AGSNDVI from east to west in Inner Mongolia, indicating that the vegetation cover gradually deteriorates in this direction. The regions of high AGSNDVI, namely the areas with good vegetation, are mainly distributed in

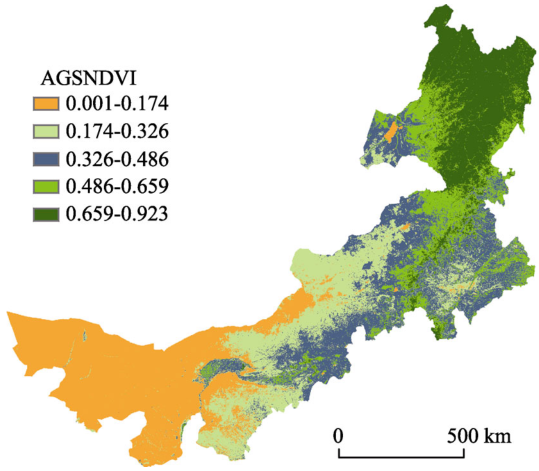

Figure 1 Spatial distribution of AGSNDVI in Inner Mongolia in 2000

the deciduous/coniferous forest area on the north Da Hinggan Mountains, which have humid and semi-humid climates, the forest-steppe zone on the middle section of the Da Hinggan Mountains, the coniferous and broad-leaved mixed forest area on the east of the pediment tableland in the Songliao Plain and the forest-steppe zone on the northern and western sides of the Da Hinggan Mountains. From northeast to southwest, the AGSNDVI gradually decreases, showing an evident transition phenomenon between dry and wet areas. The AGSNDVI has been reduced to 0.2–0.4 in the semi-arid steppe area in central Inner Mongolia, which indicates that the vegetation in this area is gradually becoming sparser. In the arid desert area of western Inner Mongolia, the AGSNDVI is less than 0.1, with the surface mainly covered by desert, gobi, bare soil and bare rock.

3.2 Annual variation of the vegetation index and its spatial pattern

The AGSNDVI increased from 0.368 to 0.405, an increase of 10.1%, in Inner Mongolia between 2000 and 2010. Considering the AGSNDVI as a whole, the wide variation in Inner Mongolia was conspicuous. The vegetation greenness showed an increasing trend as a whole.

There was a significant variation in the spatial distribution of the AGSNDVI, the changes in which were divided into five categories of ESD, SD, NSC, SI and ESI in accordance with confidence levels of 95% and 99%, as shown in Figure 2. As stated in the statistical results, 28.88% of the study area had experienced a significant increase (SI) between 2000 and 2010, of which ESI made up 17.81% (P<0.01) of the study area, SD (P<0.05) 2.19% and NSC (P>0.05) 68.93%.

Areas where the AGSNDVI reduced significantly showed a mainly banded distribution in central Inner Mongolia, along the line of Wuchuan County–Chahar (Qahar) Right Wing Middle Banner–Shangdu County–Huade County–Zhengxiangbai Banner–Zhenglan Banner–Keshikten (Hexigten) Banner, Balin (Bairin) Right Banner–Ar

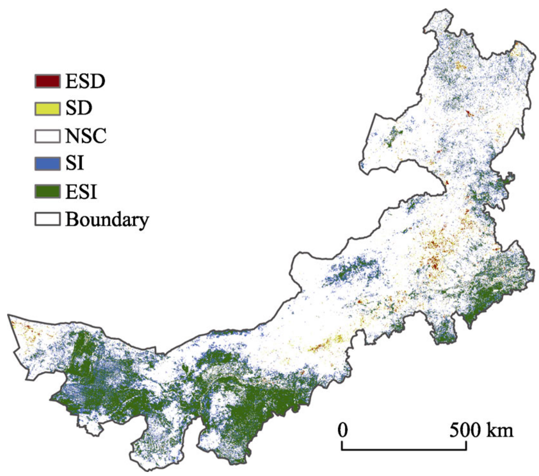

Figure 2 Spatial changes in vegetation greenness based on inter-annual trends and significance of AGSNDVI in Inner Mongolia between 2000 and 2010
ESD: extremely significant decrease; SD: significant decrease; NSC: no significant change; SI: significant increase; ESI: extremely significant increase

Horqin Banner–Jarud Banner, Horqin Right Front Banner, where the vegetation greenness appeared obviously degrading trend. The distribution of this belt is consistent with the findings of Wang, which is just located at the northern edge of the agro-pastoral ecotone in Inner Mongolia, sensitive to climate change and human activities (Niu, 1989; Wang *et al*., 2010).

The area where the AGSNDVI had significantly increased was mostly concentrated in the southeast and west of Inner Mongolia, mainly distributed in three areas: (1) the forest steppe zone in the middle part of the Songliao Plain and the montane deciduous broad-leaved forest region of northern China, which is mainly covered with typical grassland and farmland, such as Naiman Banner, Hure Banner, Harqin Banner, Ningcheng County, etc.; (2) the transition between the steppe region in eastern Inner Mongolia and the desert steppe zone in western Inner Mongolia and the Erdos Plateau, covered by typical steppe, desert steppe and farmland, such as Jungar Banner, Dalad Banner and Ejin Horo Banner and Uxin Banner; (3) the desert area in the Alax-Hexi Corridor, mainly covered by desert and desert steppe, such as Alxa Right Banner and Ejin Banner. The vegetation index increased notably during the study period in those areas, of which the first two were located in a farming-pastoral ecotone, mainly covered with cultivated land and grassland. The last one was the desert area in Inner Mongolia, where the AGSNDVI was extremely low and where the vegetation greenness had obviously improved between 2000 and 2010. In addition, as shown in Figures 2 and 4, the vegetation greenness improved significantly in the areas with a concentrated distribution of farmland, which may be related to the increase in irrigation and improvement in production facilities.

3.3 Effects of population migration on vegetation greenness

Taking the annual variation trend of the AGSNDVI in the study area as the dependent variable, the influencing factors (six indexes) selected in Table 1 were used as independent variables, and a multiple linear regression model was used to investigate the effects of various factors on the changes in vegetation greenness. Table 2 shows that the F value of this model is 4.517, indicating it is notable at the 0.001 level. The main factors affecting the inter-annual variation trend of AGSNDVI during this period, arranged in order of contribution rate, in accordance with the standard partial regression coefficients at the 0.05 level, included rate of change of QAL, variation trend in ATP, variation trend in AMT and rate of

Table 2 Explanatory model for changes in vegetation greenness in Inner Mongolia

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	Collinearity statistics	
	B	Std. error				Tolerance	VIF
Adjusted R^2: 0.263							
(Constant)	0.006	0.002		2.735	0.008		
Slope ATP	0.002	0.001	0.359	2.545	0.014**	0.629	1.590
Slope AMT	–0.343	0.169	–0.273	–2.028	0.048**	0.687	1.455
CRQAL	–0.010	0.003	–0.447	–3.134	0.003***	0.613	1.631
CRAAL	–0.031	0.019	–0.192	–1.660	0.103	0.930	1.075
CRCAPAL	–0.002	0.001	–0.265	–2.151	0.036**	0.824	1.214
CRSCPA	0.000	0.001	0.112	0.904	0.370	0.813	1.230

Note: * stands for $P<0.1$; ** stands for $P<0.05$; *** stands for $P<0.01$.

change of CAPAL. Moreover, from the orientation of the fitting coefficients, the other factors showed negative relationships with the trend in AGSNDVI, except for the trend in ATP.

Due to correlation between the independent variables, the independent variable is not independent of the dependent variable for the multiple linear regression method. Besides the direct effect of an independent variable on the dependent variable, there are also indirect effects of the variable on the dependent variable (Chen, 2000). Therefore, the standard partial regression coefficient reflects the direct effect of the independent variable on the dependent variable in the control of other variables. As shown in Table 2, the absolute value of the standard partial regression coefficient of the rate of change of QAL is greater than that of ATP. It turns out that the contribution of the outward migration of agricultural labor on changes in vegetation exceeded that of natural factors such as precipitation.

Figure 3a shows that the rate of change of QAL had the most significant effect on changes in vegetation greenness, and displayed a negative correlation. This result proves that increasing outward migration of agricultural labor reduced the population pressure, to some extent, and played a driving role in improving the local vegetation greenness.

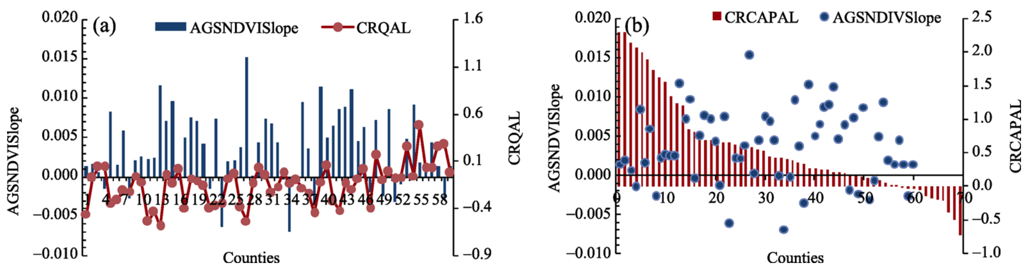

Figure 3 Spatial distribution of the variation trend of AGSNDVI and its main influencing factors in Inner Mongolia

Between 2000 and 2010, the rural labor force in Inner Mongolia changed markedly. The QAL was reduced by 16.16% in the study area, according to the census data. While the changes in QAL were obvious at the spatial scale, the reduced rate of QAL increased gradually from the northeast to the southwest (Figure 4). The areas with the most rapid decrease in QAL were in the southwestern and central districts located at the junction of two provinces. Counties such as Alxa Right Banner, Otog Banner, Xinghe County and Shangdu County, lying in the southwestern and central regions of Inner Mongolia, showed a reduction in QAL of more than 30% in ten years. Conversely, counties where the QAL changed only slightly were mainly located in the northern border area. The reduction in QAL was around 5% in these counties, such as Urad Rear

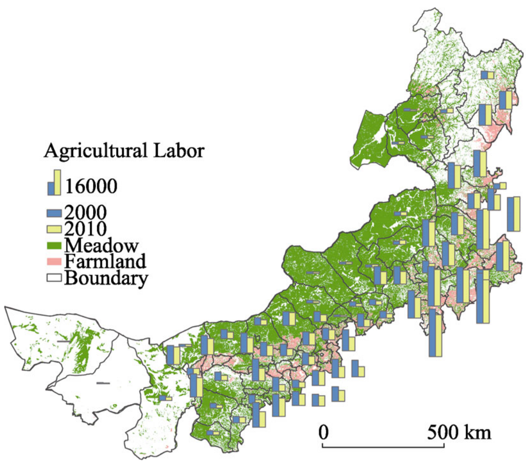

Figure 4 Spatio-temporal distribution of the agricultural labor force and its changes in Inner Mongolia during the period 2000–2010

Banner, Siziwang Banner and Sonid Left Banner. The increase in QAL was less than 5% in counties such as Ejin Banner, Abag Banner and Dong Ujimqin Banner. As shown in Figure 3a, the area with a rapid reduction in QAL was precisely the one where the vegetation improved significantly. With further growth and rapid urbanization, there will be a large number of the labor force migrating out of rural areas in the future, which should further promote improvement in the vegetation greenness under certain conditions.

Previous studies have mainly focused on the total regional population, which is still increasing in the context of the now slower growing population of China as a whole, contributing to the increasing pressure of population growth on the regional environment (Fang *et al*., 2006; Han *et al*., 2008). This paper selected QAL as the study variable and quantitatively verified the facts that the human disturbance had been alleviated through migration, and thus promoted the improvement of eco-environment in the fragile area.

Figure 3b shows that there was a negative correlation between the rate of change of CAPAL and the variation in AGSNDVI. The results were consistent with the study hypothesis, that is, with the increase in occupancy of arable land resources labor force per capita, the pressure on the regional ecosystem was enhanced from agricultural activities per capita, and the impact on the vegetation greenness was evident. This may be explained by human activities, such as the influence of farmland irrigation on the overuse of groundwater or over-farming of the regional eco-environment. During 2000–2010, the CAPAL increased from 9.96 ha to 14.53 ha in the study area, an increase of 45.86%, indicating that the activity of per unit labor force increased significantly.

The change in trend of ATP was significantly and positively related to the trend in AGSNDVI at the county scale. Moisture was an important controlling factor for vegetation growth and ecological construction in both arid and semi-arid areas. The faster the increase in ATP, the higher the AGSNDIV was during the study period, and vice versa. Previous studies have obtained similar results on the grid-cell scale, namely, there was a good positive correlation between AGSNDVI and ATP in Inner Mongolia at the inter-annual scale (Sun *et al*., 2010; Mu *et al*., 2012; Zhang *et al*., 2013).

The adjusted R^2 of this interpretation model was 0.263 (Table 2), indicating that the total contribution rate of the six variables was 26.3% to explain the variation trend of AGSNDVI on a decadal timescale. For cross-section data, owing to differences in sample characteristics, the R^2 of the regression analysis does not need to be too high, generally higher than 0.2 can be accepted (Zhang, 2004), which also means that there may be other explanatory variables not included in this model. A variety of ecological engineering programs (i.e., Grain for Green Project, Beijing-Tianjin Sandstorm Source Control and Three-Norths Shelterbelt Program) have promoted the recovery of vegetation greenness in Inner Mongolia (Hu *et al*., 2010) and offset the destructive effect of mineral mining on the local grassland vegetation. These factors were not considered in this study, by reason of the difficulty in data acquisition as these variables are needed to be quantitatively expressed. Thus, we have focused only on the effects of the agricultural labor force and its agriculture and animal husbandry production activities.

4 Conclusions

Over the past ten years, Inner Mongolia has experienced a rapid increase in urbanization, with a large number of the labor force migrating out of rural areas. Against this background, the trend line analysis method and the testing of significance were used to investigate the variation trend of vegetation greenness in Inner Mongolia between 2000 and 2010, with NDVI as the index to quantify vegetation greenness. The influence of population migration on vegetation greenness was analyzed quantitatively by means of multiple regression analysis. The results showed that:

(1) Between 2000 and 2010, the AGSNDVI showed an overall rising trend, with an increase of 10.1% during this period. The variation in spatial pattern was obvious – more than 28% of the area improved significantly – and only a few parts (about 2%) degenerated considerably.

(2) The regions where the vegetation was significantly degraded were mainly distributed in central Inner Mongolia, located at the northern edge of the agro-pastoral ecotone. The eco-environment in this area was still relatively fragile, more attention should be paid. The areas where the vegetation greenness increased significantly were largely concentrated in southeastern and western Inner Mongolia.

(3) The migration of large numbers of the rural labor force eased the pressure of population on the ecosystem at the county scale, to some extent, promoting improvement in the local vegetation greenness. Furthermore, the contribution of rural labor migration to vegetation greenness exceeded that of natural factors. From the perspective of ecological restoration, rural labor migration achieved a win-win ecological-economic significance. Therefore, government departments should formulate a reasonable urban development plan and create more off-farm jobs to attract transfer of the agricultural labor force, promoting an improvement in vegetation in ecologically fragile areas.

However, although population pressure has reduced, the intensity of agricultural production activities of the unit labor force has increased, and it had a significant effect on regional vegetation greenness. Consequently, more attention should be paid to the destruction by agricultural production activities of the eco-environment in those areas.

The impacts of population changes on the production environment in fragile areas are divided into two aspects, namely, the role of population increase and that of population decrease. Against the background of a steady increase in total population in China, the role of population on the regional environment is still increasing in pressure. In this paper, the rural area, with a very large amount of the labor force migration, was chosen as the object of study, quantitatively illustrated the process that the migration reduced the population pressure and then improved the environment in ecologically fragile areas.

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