Impacts of Land Use Change on NDVI in Shaanxi Province of China

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Abstract. Land use change is one of the main impacts of human activities and has a profound impact on vegetation change. Based on the MODIS normalized difference vegetation index (NDVI) from 2000 to 2018 and land use data in 2000, 2005, 2010, and 2015, the land use and its impacts on NDVI change in the Shaanxi province of China were analyzed. This study showed that the land use structure in Shaanxi province is stable, with forest land, grassland and farmland as the main components. The main feature of land use change from 2000 to 2015 was the large area of farmland converted to construction land, mainly distributed in the Guanzhong Plain in the central Shaanxi province, especially in the vicinity of the capital city of Xi’an. The impact of land use changes on NDVI showed a significant decreasing trend in the area converted to construction land during 2000-2018, while the NDVI for areas converted to forest, farmland and grassland all showed a significant increasing trend. The growth rate of NDVI in the area converted to farmland was higher than in the areas converted to forest land and grassland, the reason for which needs further study.

1. Introduction
Land use change is a key issue which has received a lot of recent academic interest. As one of the main impacts of human activities, land use has profoundly changed the face of the Earth and has caused a series of ecological and environmental problems[1-2]. Among the two major drivers of global warming, land use change is the most important driving force excluding the burning of fossil fuels[3]. Land use changes driven by human activities have occurred from several different types of development. For example, urban expansion along with economic and social development had led to the conversion of farmland, forest land and grassland to construction land. The implementation of ecological construction projects has also led to returning farmland to forest land and grassland[4-5]. Since the 1990s, land use change has received extensive attention; after decades of research, the focus of land use change studies has shifted from the process of land use spatio-temporal change, to land use ecological effect, land use function and other aspects[6-8]. Shaanxi province is a key area for the implementation of projects which return farmland to forest land and grassland, as ecological changes are caused by both human activities and climate change. The study on the impacts of land use change on vegetation, using the normalized difference vegetation index (NDVI), is important to determine the theoretical and practical significance of regulating human activities and to inform ecological protection and construction policies.
2. Data and Method

2.1. Data
(1) MOD13Q1 NDVI data from 2000 to 2018 was used. The dataset has a spatial resolution of 250 m and a temporal resolution of 16 days (d). The maximum value composition method was used to obtain annual time series data. (2) The land use cover dataset has a 300 m resolution, obtained from the European Space Agency in 2000, 2005, 2010 and 2015 (downloaded from http://www.globallandcover.com). Six types of land use cover are found in the dataset: farmland, forest land, grassland, water body, construction land, and unused land.

2.2. Method
The research used conventional geographical information methods and calculation methods of land use change amount and rate. For related analysis methods, see reference [4].

3. Results

3.1. Temporal change process of land use
The area of various land use types in 2000, 2005, 2010 and 2015, and the area of changes and proportions of land use types were calculated in Shaanxi province from 2000 to 2015 (Figure 1). From 2000 to 2015, the land use structure in Shaanxi province was relatively stable, composed mainly of forest land, farmland, and grassland, which accounted for 40.84%, 34.58% and 23.37% of the total area of the Shaanxi province, respectively. Water bodies, construction land and unused land occupied a small proportion. The areas of farmland, grassland, water bodies and unused land showed reduced areas between 2000 and 2015, with the largest reduction observed for farmland area which decreased by 2344.59 km², accounting for 79.39% of the total reduction in land use type. There was also a smaller decrease in land use for grassland, losing 469.44 km² and accounting for 15.89% of land use change. The land use types with the increased area were mainly for construction land and forest land, with large increases of 244800 km² and 505.44 km², and accounting for 82.89% and 17.11% of the increase in land use type, respectively (Figure 1a). In terms of land use change rate, construction land had the highest rate of increase between 2000 and 2015 at 453.94%, while unused land showed the biggest decrease in rate at -20.47% (Figure 1b).

Using overlay analysis, the land use transform matrix of Shaanxi province from 2000 to 2015 was calculated (Table 1). The results showed that from 2000 to 2015, the farmland in Shaanxi province...
was mainly converted to construction land, grassland and forest land. Forest land was mainly converted into farmland and grassland. Grassland was mainly converted into forest land, construction land and farmland. Unused land was mainly converted into grassland. The conversion area of water bodies and construction land was relatively small. In terms of land use type in 2015, farmland was mainly transformed from grassland and forest land, while forest land was mainly converted from grassland and farmland, grassland was mainly transformed from farmland and forest land and construction land was mainly converted from farmland and grassland. The conversion area of water bodies and unused land was small.

Table 1. Change Matrix of land use area from 2000 to 2015

| 2000-2015 | Farmland (km²) | Forest land (km²) | Grassland (km²) | Water body (km²) | Construction land (km²) | Unused land (km²) |
|-----------|----------------|-------------------|----------------|------------------|------------------------|------------------|
| Farmland  | 849.70         | 145.08            | 345.96         | 0.00             | 2153.07                | 0.27             |
| Forest land | 109.80      | 96 541.56         | 106.11         | 0.00             | 9.63                   | 0.00             |
| Grassland | 189.45         | 585.90            | 54905.31       | 0.00             | 279.00                 | 2.79             |
| Water body | 0.54         | 0.00              | 0.54           | 452.79           | 1.80                   | 0.09             |
| Construction land | 0.00    | 0.00              | 0.00           | 0.00             | 539.28                 | 0.00             |
| Unused land | 0.00        | 0.00              | 135.09         | 0.00             | 4.50                   | 527.04           |

3.2. Spatial distribution of changes in land use (2000-2015)

The grassland in Shaanxi province was concentrated in the northern region, while the farmland was concentrated in the central region and the forest land was concentrated in the southern, central and northern regions. The distribution of other land use areas was scattered (Figure 2a-d). In general, the distribution of the changes in land use type across the Shaanxi province from 2000 to 2015 was also scattered (Figure 2e), with the largest area of land use change occurring as a result of farmland being converted to construction land (Figure 2f). This conversion of farmland to construction land was mainly concentrated in the vicinity of Xi’an City in central Shaanxi province.
Figure 2. Spatial distribution of land use in 2000 (a), 2005 (b), 2010 (c) and 2015(d), and land use transform (e, f) during 2000-2015.

3.3. Impacts of land use change on NDVI
Changes in NDVI from 2000 to 2018 across the areas of different land use types were analyzed to explore the impact of land use change on NDVI (Figure 3). Across the Shaanxi province, NDVI showed a significant increase from 2000 to 2018, particularly where farmland was converted to forest land and grassland, with a higher growth rate in the NDVI in areas converted to grassland than forest land (Figure 3a-b). Meanwhile, the area converted from farmland to construction land showed a significant decrease in NDVI (Figure 3c). The NDVI of forestland areas converted to farmland and grassland both showed a significant increase, with higher NDVI growth rates in areas of forestland converted to farmland than grassland (Figure 3d-e). Similarly, the NDVI of areas of grassland converted to farmland and forest land also showed significant increasing trends, with higher NDVI growth rates in areas of grassland which were converted to farmland than forest land (Figure 3f-g). However, the NDVI of grassland areas converted to construction land showed a significant decrease (Figure 3h). The NDVI in the areas of unused land which were converted to grassland showed a significant increase (Figure 3i).
Figure 3. NDVI changes in the Shaanxi province between 2000 and 2018: NDVI change in the areas of farmland converted to forest land (a), grassland (b) and construction land (c); NDVI changes in the areas of forest land converted to farmland (d) and grassland (e); NDVI changes in the areas of grassland converted to farmland (f), forest land (g) and construction land (h); NDVI changes in the areas of unused land converted to grassland (i).
4. Conclusions
Based on MODIS NDVI from 2000 to 2018 and land use data in 2000, 2005, 2010 and 2015, the land use change in the Shaanxi province and the impact on NDVI change were analyzed. This study showed that the land use structure of the Shaanxi province was stable, with forest land, grassland and farmland as the main components. The main characteristics of land use change between 2000 and 2015 were the large reduction of farmland and the increase of construction land. While the area of farmland decreased by 2344.59 km², accounting for 79.39% of the loss across land use types, the area of construction land increased by 2448.00 km², accounting for 8289% of the gain across land use types, with a growth rate up to 453.94%. Land use transformation was dominantly represented by the conversion of farmland to construction land, most commonly in the Guanzhong Plain in central Shaanxi province and particularly in the vicinity of the capital city of Xi’an. The impact of land use change on NDVI was characterized by a significant decrease in the regions that were converted to construction land from 2000 to 2018, while the NDVI of areas converted to forest land, farmland and grassland all showed a significant increase. The NDVI growth rates were highest in areas converted to farmland than those transformed into forest land and grassland, the reason for which will require further study.

Acknowledgments
This work was supported by the Key Research and Development Program of Shaanxi (2018ZDXM-GY-027).

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