Ecosystem Services 31 (2018) 12–20

Contents lists available at ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser

Effects of land use change on ecosystem services value in West Jilin since the reform and opening of China

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ARTICLE INFO

Article history:
Received 30 October 2016
Received in revised form 15 March 2018
Accepted 19 March 2018

Keywords:
Land use change
Ecosystem services value
Reform and opening of China
West Jilin

ABSTRACT

Land resources were the foundation of human survival and development. The change of land use altered the pattern of vegetation and landscape, caused the change of ecosystem structure and function and changed the value of regional ecosystem services. This study spatially and quantitatively explored the impact of land use change on the ecosystem service value in West Jilin since the reform and opening of China. The results showed that the main characteristic of land use change in West Jilin was area reduction in grassland and marsh and area increase in arable land and alkali-land. However, land use change in Period I (1976–2000) got a faster rate than in Period II (2000–2013). Land use change resulted in the ESV in West Jilin decreased by 1334 million yuan since the reform and opening up of China, with an annual loss of 39.2 million yuan in Period I and 30.2 million yuan in Period II. The conversion of marsh to other types land use was the primary land use reason for the decrease in ESV. Alkali-land expanded quickly in Period I, however, the trend of salinization turned to be curbed and the area of alkali-land began to decrease after 2000, which increased the ESV by about 234 million yuan. Due to the concern of local government and relevant scientific research departments, the ecological and environmental deterioration were meliorated and the decrease rate of ecosystem services value also slowed down. Excitingly, ESV even increased in some areas on account of land use was becoming more rational.

1. Introduction

Land was a complex system that was constantly developing and evolving under the long-standing interaction of nature and human activity (Turner et al., 1992, 1995; Lambin et al., 2001, 2003). In order to meet certain economic or social purposes, people developed and operated the land and formed land use (Gutman, 2004). Therefore, land use was a social phenomenon based on natural conditions and had profound ecological and environmental effects (Rindfuss et al., 2004). Land use played a decisive role in maintaining ecosystem services (Collard and Zammit, 2006; Bateman et al., 2013). Changes in land use patterns and corresponding changes in the coverage pattern would inevitably lead to changes in the ecosystem structure and thus to the ecosystem services (Haberl et al., 2001; Lorencová et al., 2013). Land use/land cover change was the most direct manifestation of the interaction between human activities and the natural environment (Khan et al., 2015; Roth et al., 2016). The eco-environmental effect of land-use change was an important part of the research on global climate change and global environmental change (Dubreuil et al., 2012; Daniel et al., 2015; Natkhin et al., 2015).

The ecological and environmental effects of land use change could be characterized from ecological footprint (Rees, 1992; Butler et al., 2007; Zhou et al., 2009), eco-environmental quality index (Cui and Zang, 2013) and ecosystem services value (ESV) (Lautenbach et al., 2011; Kindu et al., 2016), etc. In the past few decades, China had paid so much attention to the growth of its GDP as a result of its emphasis on economic development. Therefore, choosing the ecosystem services value that can be expressed in the form of monetary value to quantify the ecological and environmental effects of land-use change will even arouse the warnings of relevant managers and decision-makers. Ecosystem Services (ES) refered to the welfare and benefits derived from ecosystems that directly or indirectly supporting human survival and development (Daily, 1997). Due to the close relationship between ecosystem services and the quality of human lives, many scholars had been devoting themselves to the quantitative study of the ecosystem services value in order to estimate and evaluate

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https://doi.org/10.1016/j.ecoser.2018.03.009
2212-0416/

them globally (Peters et al., 1989; Pimentel et al., 1995; Turner et al., 1998; Sherrouse et al., 2011; Costanza et al., 1997; Costanza et al., 2014; Bunse et al., 2015; Xie et al., 2015). Costanza realized the monetary expression of ESV by summing up previous studies (Costanza et al., 1997, 2014). Based on the evaluation model proposed by Costanza, Xie et al (2003, 2015) formulated the table of ecosystem services value per unit area of different terrestrial ecosystems in China, which was concise and reliable and has been widely used in China (Yue et al., 2007; Li et al., 2016).

On this basis, many scholars had studied the change of ecosystem service value caused by land use change. For examples, Song et al (2015) analyzed the impacts of rapid urbanization on the ecosystem service value in the North China Plain; Kindu et al (2016) showed an estimate of changes in ESV in response to LULC dynamics over the past four decades (1973–2012) by using Munessa-Shashemene landscape of the Ethiopian highlands as an example; Sherrouse et al (2017) analyzed land use change scenarios to quantify changes in aesthetic and recreational ecosystem service values and assessed trade-offs between these values relative to forest stakeholder groups defined by their attitudes regarding motorized recreation. These studies provided profound insight into the eco-environmental effects of land use change in a region scale, however, they all overlooked an important fact more or less, i.e., the ecosystem services provided by the same type of ecosystem in different regions were not the same owing to the objective existence of regional differences in climate and environment. Moreover, the ESV method of valuation was a supply side valuation, where the value was determined only by the potential supply of ecosystem services per land use class multiplied with a unit monetary value per ecosystem service within that class. The real economic value of an ecosystem services was determined in the interaction between supply by ecosystems and demand by people/society. Therefore, the Pay Index (PI) was introduced to reflect the people/society demand for ecosystem services in this article and West Jilin was selected as the study area for spatially and quantitatively exploring the impact of land use change on the ecosystem service value based on the spatial analysis method of GIS and the research of Xie et al (2003).

Since the reform and opening up, China's economy has experienced rapid development for nearly 40 years. After 2013, the GDP growth rate has slowed down. From the reform and opening up of China to 2013, West Jilin, with the most vulnerable ecological environment in Northeast China, experienced drastic changes in land use pattern and had a significant impact on ecosystem service value under the dual influence of human activities and global climate change (Li et al., 2016). This process can be divided into two periods; before 2000, driven by economic interests, a large amount of grassland, woodland and wetland were reclaimed as farmland, which completely neglecting the natural laws of landscape ecological evolution; after 2000, the ecological consequences of irrational land use began to attract the attention of managers and researchers, China promulgated corresponding laws and invested a large amount of ecological restoration funds to promote the construction of ecological civilization.

Therefore, this study focuses on the spatial and quantitative analysis of the differences in the impacts of land use change on ecosystem service value in West Jilin between Period I (1976–2000) and Period II (2000–2013). It not only can deeply understand the regional differences in the ecological and environmental effects of land use change, but also helpful to objectively evaluate the ecological civilization construction in China.

2. Data and methods

2.1. Study area

West Jilin locats in the Northeast China (43°59′N–46°18′N, 121°38′E–126°12′E) and includs 10 counties named Baicheng, Changlin, Da'an, Fuyu, Qian'an, Qianguo, Songyuan, Taonan, Tongyu and Zhenlai; the total area was about 46,900 km^2 (Fig. 1). West Jilin is a transitional area from semi-arid to sub-humid areas with poor ecosystem stability and resilience and also is one of the three regions that salinized soils distributed in the world. Most of West Jilin belongs to the temperate and semi-humid climate, while the western part belongs to the temperate and semi-arid climate. The annual precipitation is 370–407 mm; the annual evaporation is 1500–1900 mm; the annual accumulated temperature of ≥10 °C is 2900–3200 °C; the moisture coefficient is about 0.5. The average temperature in West Jilin increased by 1.5 °C, higher than the global average, and the multi-year average precipitation reduced by 60 mm in recent 38 years (Chen et al., 2011; Shen et al., 2014). West Jilin was once amid lush green prairie; however, due to the rapid population growth and over-exploitation of natural resources, the human activities are increasingly disturbing to the ecological environment. The ecological environment problems such as land desertification, salinization and pasture degradation seriously affect and restrict the development both of natural ecology and social economy (Li et al., 2015, 2016).

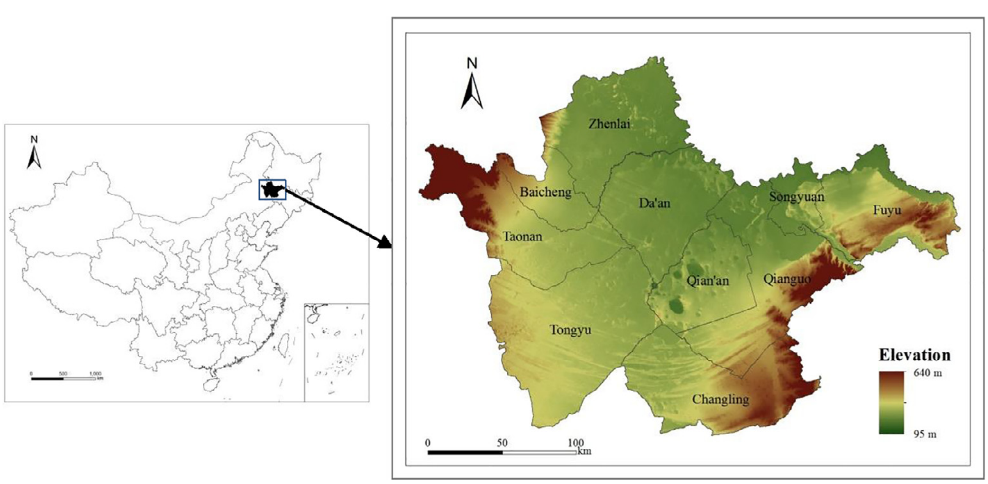

Fig. 1. Location of West Jilin.