



Linking land use change, ecosystem services and human well-being: A case study of the Manas River Basin of Xinjiang, China



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ABSTRACT

The relationship between LUCC (land-use and land-cover change), ecosystem services and human well-being is not only an important cross topic in studies of natural ecological and social economic systems but also the key research direction and content of the GLP (Global Land Project) and Future Earth program, indicating its significance to the development of regional policy and the promotion of regional sustainable development. In the present study, “3S” (GIS, RS, GPS) technology, the Equivalence Factor Evaluation Method of Ecosystem Services and the Index System Evaluation Method of Human Well-being were separately used to analyze land use changes, ecosystem services and human well-being in the Manas River Basin in 2003 and 2013 and to characterize the relationship between these factors. The following conclusions were drawn: 1. In the past ten years, driven by the market economy, the structure of land use in the basin has obviously changed. Croplands and developed lands markedly increased, leading to a marked reduction in aquatic, grassland and woodland regions. 2. The land use changes resulted in a large increase in human economic income, in contrast with the obvious decrease in the value of climate regulation, gas regulation and other various types of ecosystem services influenced by the decrease in grasslands, woodlands and aquatic regions. 3. Most aspects of human well-being were improved. The most important aspect was the economic income well-being as a result of land use changes. However, the well-being associated with natural ecological resources showed a significant decline. 4. The extreme increase of croplands and developed lands has resulted in a structural imbalance of the ecosystem services and abnormal development of the structure of human well-being. Thus, to enhance the stability of the “nature-society-economy” system of the basin and pursue sustainable development, it is imperative to slow down or even stop the existing development trend of land use, and it is urgent to improve the structure of ecosystem services and human well-being.

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1. Introduction

The relationship between ecosystem services and human well-being under land use changes is an important cross topic in research concerning natural ecosystems and social economies. Land use is one of the most closely associated links between man and nature. Land use changes will inevitably affect the structure of natural ecosystems and subsequently change ecosystem services. Ecosystem services are the benefits directly or indirectly obtained by humans from the ecosystem, including support, provisions, regulations and cultural services (Costanza et al., 1997,

2014; MA, 2005). Human well-being is based on the experiences of the people who believe that there is value in activities and status, including maintenance of the basic material conditions of a high quality of life, health, good social relations, security and freedom of choice and action (MA, 2005). Humans are an integral part of ecosystems and they tradeoff ecosystem services by changing the manner, pattern, scale and intensity of land use, leading to changes in their well-being. The correlation between ecosystems and human well-being is positive. However, because different stakeholders are interested in different ecosystem services, the relationship between different stakeholders and overall well-being is not a simple sum-total relationship (Li et al., 2014). The optimal combination of ecosystem services, which varies with region, produces maximum human well-being. Increased research efforts concerning the relationship between ecosystem services

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and human welfare under land use changes are urgently needed to improve theory and practice (Groot et al., 2012).

As an extension of the LUCC program, the GLP (Global Land Project), a core program jointly released by the IGBP (International Geosphere-Biosphere Program) and IHDP (International Human Dimensions Program on Global Environmental Change) focuses on the coupling relationship between changes in land use, the global climate, ecosystems and human society by considering the changes in ecosystem services resulting from land use changes as important research content (Gong et al., 2014a,b). In 2012, the ICSU (International Council for Science), ISSC (International Social Science Council) and other institutions jointly launched the Future Earth program. This effort proposed that the strategic framework for the next 10 years should involve a “sustainable development route”, focusing on global environmental changes, natural and human-driven global environmental changes, human well-being and the relationship between all three of these aspects (Xin and Wang, 2015; Wu et al., 2015). “FutureEarth”, GLP, ecoSERVICES (Ecosystem Services) and ecoHEALTH (Ecosystem Health) worked together and established a global organization, the interdisciplinary scientific cooperation platform. Under this background, the core topics “Supply changes of ecosystem services caused by land use change,” in GLP, “Assessing the impact of ecosystem services change on human well-being and human response to changes in ecosystem services” in ecoSERVICES, and so on will become the key contents of the Future Earth program. Indeed, the study of ecosystem services and human well-being under land use change will become the focus of current and future research primarily because there is a close relationship between land use change and ecosystem service, which directly or indirectly affects the ecological system structure and process and changes the abilities of ecosystem services that profoundly impact human well-being (Fu and Liu, 2014; Fu and Zhang, 2014).

Recently, several studies concerning the relationship between land use changes and ecosystem services, land use changes and human well-being or ecosystem services and human well-being have been reported. Land use changes, such as the core field of global environmental change, influence the structure and function of the ecological system, playing a decisive role in the function of ecosystem services, and an assessment of the ecosystem services value can be used to assess the ecological effects of land use planning and play a guiding role in land use planning (Zhao et al., 2013; Lawler et al., 2014). Bateman published a simulation of the interactions between the value of ecosystem services and land use policies in *Science* (Bateman et al., 2013). Lopes studied the effect of land use on the distributive issues of ecosystem services, concluding that different types of land use generate a very asymmetric distribution of income among different groups of humans: land owners, citizens of a country, and residents of earth (Lopes et al., 2015). Milner examined how land use transitions to second-generation bioenergy crops potentially impact the ecosystem services in GB (Milner et al., 2016). Furthermore, many experts have analyzed the interaction between LUCC and ecosystem services, revealing their relationship (Tolessa et al., 2017; Loc et al., 2016; Zhang et al., 2016). In addition, Gasparatos systematically introduced the related driving force, influence factors and biofuel production balance of ecosystem services and human well-being, concluding that the production and use of biofuels can directly or indirectly affect all aspects of human well-being (Gasparatos et al., 2011). Horcea-Milcu implemented a case study in Eastern Europe to clarify the disaggregated contributions of ecosystem services to human well-being, analyzing the relationship between ecosystem services and human well-being using a model and concluding that people in poor regions are more dependent on ecosystem services (Horcea-Milcu et al., 2016). Bennett have suggested that the current research on ecosystem services and human

well-being have many shortcomings. In addition, these researchers suggested three strategies for improving the value of ecosystem services, human well-being and regional sustainable development (Bennett et al., 2015). Recently, many results about ecosystem services and human well-being have been obtained, promoting the development of this field (Delgado and Marín, 2016; Bryce et al., 2016). However, studies on land use changes, ecosystem services and human well-being are few, and these topics have only recently been studied in earnest. For example, in Huailai County, China, Xu analyzed the effects of land use intensity on major aspects of ecosystem services, such as grain production, soil and water conservation and climate regulation, and human well-being, particularly in terms of life and food security, by establishing the index system. The results suggested that the changing trend of ecosystem services and human well-being strongly support the development of land use policies (Xu et al., 2016). Quintas-Soriano analyzed the contradiction between economic development and the ecosystem in the arid region of southeast Spain, discussing the effects of different land use patterns on ecosystem services and characterizing the attitudes of local people to the status quo of human well-being using a questionnaire survey. The data were analyzed to obtain an understanding of the arguments affecting the improvement of land use changes and visualize the trade-offs of ecosystem services under different management strategies (Quintas-Soriano et al., 2016).

Many problems in research concerning land use changes, ecosystem services and human well-being need further study (Bennett et al., 2015). For example, one of the greatest difficulties for researchers is the lack of reliable data sources, which leads to results based on unreliable data (Fu and Liu, 2014; Fu and Zhang, 2014). Most researchers only discuss the changes in different periods, without revealing the structure and process (Eigenbrod et al., 2010; Burkhard et al., 2012). Thus, the results of these assessments of ecosystem services value and human well-being are restricted under some assumptions, and the validity of land use decision making is questioned (Fu and Liu, 2014; Fu and Zhang, 2014). All these problems make it difficult to develop relevant policies for a specific region, and the goal of developing the best ecosystem services and human well-being is not achieved. With an increasing demand for incorporating ecosystem services into land use decision-making, the deep relationship between ecosystem services and human well-being under land use changes becomes increasingly important.

The Manas River Basin, in the northern slope of the Tianshan Mountains, is an inland river basin that features an arid zone in the southern margin of the Junggar Basin. Oasis development and economic development are key models of the entire Xinjiang Uygur Autonomous Region, and even of China and the world. In this region, over the past 60 years, land use changes have generated significant economic benefits (Cheng et al., 2006). However, with the development of the social economy, environmental and economic problems resulting from land use changes have gradually appeared. Based on the results of previous studies involving the Manas River Basin as a key study area, we analyzed the complex relationship between land use changes, ecosystem services and human well-being to clarify the process and mechanism of ecosystem services in theory and to increase human well-being and promote sustainable development in policy making for the Manas River Basin in practice.

2. Framework, materials and methods

2.1. Framework

The relationship among land use change, ecosystem services and human well-being are explained in Fig. 1, which is the sources of this study's inspiration.

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