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Agricultural landscape dynamics in response to economic transition: Comparisons between different spatial planning zones in Ningbo region, China

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ABSTRACT

Many major agricultural regions worldwide are experiencing drastic landscape transformations. Examining the complex links among agricultural landscape dynamics (ALD), land use and land cover (LULC) change, socioeconomic development and government planning is pivotal to enhance the efficiency of agricultural landscape management. With a case of the Ningbo region (China), this paper employs the structural equation modeling (SEM) to quantify and compare the relationships between ALD and economic transition as well as the mediating LULC factors in different spatial planning zones. ALD are quantified by time series remotely sensed imageries and a set of landscape metrics; and economic transition is described by a set of indicators from three aspects (globalization, decentralization and marketization). Results show that ALD present similar trend in the two spatial planning zones between 1979 and 2013. However, the magnitude of ALD is larger in the non-urban planning zone. In particular, agricultural landscapes change into the fragmented, irregular, decreased, and isolated patterns at a more rapid pace. Economic transition drivers and LULC mediators differ remarkably between the two spatial planning zones. For the urban planning zone, economic transition influences ALD through construction land morphological changes and water body spatial density increases. For the non-urban planning zone, economic transition influences ALD through forest morphological changes and construction land spatial density increases. In addition, the relative importance of ALD determinants differs between the two spatial planning zones. Marketization plays a more critical role in driving ALD in the urban planning zone, while decentralization has a stronger impact on ALD in the non-urban planning zone. It is argued that land use master plan for agricultural landscape protection should be implemented in the non-urban planning zones and land use plan in the two spatial planning zones should be integrated. This study contributes to the understanding of the complex mechanism of ALD in response to economic transition.

1. Introduction

Although agricultural land generates phenomenal productivity for human benefits, food security remains to be a persistent challenge for global sustainability (Brown and Schulte, 2011; FAO, 2009). Many major agricultural regions worldwide, especially in the Asia, are experiencing drastic non-agricultural utilization that features agricultural land abandonment and conversion to construction land (Long et al., 2009; Pandey and Seto, 2015; Pribadi and Pauleit, 2015; Sreeja et al., 2015). There is growing concern that Asian agriculture, especially in the developing countries, lacks of resilience, capacity and sustainability (Huang et al., 2009; Padgham et al., 2015; Su et al., 2016a; Xiao et al., 2015). Many observations signified that continuous non-agricultural utilization can deteriorate the eco-environment (García-Ruiz and Lana-Renault, 2011; Hou et al., 2014; Mekasha et al., 2014), since agricultural land cover changes alter ecosystem service delivery in a significant manner (Klimek et al., 2014; Lee et al., 2015; Potgietera et al., 2015). Under these circumstances, it has stimulated widespread discussion on the potential determinants and solutions associated with the non-agricultural utilization of agricultural resources (Long et al., 2009; Paül and McKenzie, 2013; Song et al., 2015; Su and Xiao, 2013; Wu et al., 2009; Zhou et al., 2015).

Scientists nowadays explicitly call for the practice of resource conservation at landscape level (Sowińska-Świerkosz and Soszyński, 2014), as the efficiency has been proven by numerous cases at local, regional and global scales (Kienast et al., 2015). "Landscape agronomy" in particular provides an appropriate perspective to address the challenges associated with non-agricultural utilization (Benoît et al., 2012). This field of agronomy analyzes the agricultural landscapes dynamics (ALD) to assist dealing with

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the resource management problems in agriculture (Deboliniet al., 2013; Kirchner et al., 2015; Liang et al., 2015; Murgue et al., 2015; Su et al., 2011, 2014a). The ALD refer to the dynamic changes of spatial configuration (pattern) and composition (number and nature) of the areas subjected to agricultural activities (Fu et al., 2006; Lee et al., 2015; Murgue et al., 2015; Paracchini et al., 2015; Su et al., 2011). Both or one dimension (configuration and composition) as well as different land use characteristics of agricultural landscapes can be quantified according to the topic of interest (Benoît et al., 2012; Murgue et al., 2015). When dealing with the non-agricultural utilization issue, the researchers have to analyze the process, determinants and consequences of ALD (Su et al., 2011, 2014a). For example, the European Landscape Convention advocates the devotions and efforts to identify the determinants of ALD (Council of Europe, 2000). Characterizing the determinants of ALD has therefore become a major priority in agricultural resource management and policy making.

Land use and land cover (LULC) change as well as abiotic and biotic factors have been identified as the direct determinants in shaping landscape patterns (Abdullah and Nakagoshi, 2006; Baus et al., 2014; Hernández et al., 2015; Liu et al., 2016; Zhang et al., 2016). In particular, the influence of LULC is more significant in regions where human occupancy has a long history (Parcerisas et al., 2012). As the major drivers of LULC change, socioeconomic development has strong impacts on landscape structures and functions (Abdullah and Nakagoshi, 2006; Parcerisas et al., 2012; Su et al., 2014a). Numerous studies have demonstrated that socioeconomic factors are critical indirect determinants of landscape pattern changes (Liu et al., 2016; Parcerisas et al., 2012; Su et al., 2014b; Xu et al., 2014). Socioeconomic development, however, is usually driven by official policy and planning (Abdullah and Nakagoshi, 2006; Xie et al., 2005). Therefore, the occurrences of LULC and landscape pattern changes driven by socioeconomics are subjected to official development policy and planning (Abdullah and Nakagoshi, 2006; Huang et al., 2009). In this regard, examining the complex links among LULC, ALD, socioeconomic development, and official planning is pivotal to enhance the efficiency of agricultural management.

China acts as a unique example for this specific topic. After the 1978s, the whole nation fundamentally transformed to market economy from the original socialism. Local government is granted authority to approve land use by the land market reform (Tao et al., 2010). The post-socialist cities, especially those located in the coastal zones, gradually reconstruct agricultural land market, separate usage right from property in agricultural land and charge agricultural land (prices, fees and taxes) (Su et al., 2011). Besides, economic restructuring is enhanced by the globalization, given China's rapid mixing into the world economic system (Huang et al., 2015; You, 2016a). Driven by the economic transition, agricultural landscapes in China decrease in dominance and configure in patterns at an accelerating pace (Fu et al., 2006; Huang et al., 2009; Liang et al., 2015; Su et al., 2011, 2014a). Land use planning has been implemented officially to restrain the non-agricultural utilization (Zhou et al., 2015). However, the land use planning fails to play the expected role, because land use is under the control of two different spatial planning systems (the urban planning zone and the non-urban planning zone), which lead to the discrepancy in land control (Liu et al., 2016; Zhou et al., 2015). Under the circumstances, comparing the mechanism of ALD in response to economic transition between different spatial planning zones should provide a typical case for the topic under investigation. However, rather few efforts have been made in this respect.

Scholars have generally agreed that remote sensing, geographical information system (GIS) and landscape metrics are efficient tools for describing and understanding landscape dynamics (Liu et al., 2016; Parcerisas et al., 2012; Su et al., 2014c; Zhang et al., 2016; Zhou et al., 2015). Structural equation modeling (SEM) is a multivariate statistical technique that attempts to estimate the causal pathways and quantify the direct or indirect relationships among multiple variables (Kelloway, 1998; Ullman, 2007). Through developing a hypothesized model and reproducing the covariance structure of the original data, SEM allows for the explicit test of mediating effect, where a third variable mediates the causality between two variables (Kelloway, 1998; Ullman, 2007). Some pilot studies demonstrate that SEM is suitable for agro-environmental studies at the level of landscape, ecosystem and community (Hong and Jeon, 2015; Pollman, 2014; Sanchez et al., 2015; Santibáñez-Andrade et al., 2015; Su et al., 2016b; Wan and Su, 2016). However, few studies have applied the SEM to investigate the relationships between ALD and economic transition as well as the mediating factors.

Against the above backdrop, this paper attempts to analyze the ALD in response to economic transition and compare the differences between different spatial planning zones. I apply remote sensing, GIS, landscape metrics and SEM into the case of Ningbo region, one of major agricultural production bases in eastern coastal China. The specific objectives are to: (1) characterize the relationships between agricultural landscape dynamics and economic transition; (2) examine their causal pathway and the mediating role of LULC; and (3) compare the differences between different spatial planning zones and provide some policy References

2. Literature and conceptual framework

2.1. Literature review

Literature on economic transition mainly focused on former socialist countries (the Soviet Union, China, and Vietnam) (Havel, 2014; Kemper et al., 2015; Li et al., 2015; Müller et al., 2013; Su et al., 2011; Zeković et al., 2015) and some developing countries (e.g., India and Bulgaria) (Ivanova et al., 2006; Mittal and Kashyap, 2015). It has been argued that the most significant changes included the separation of land use rights from ownership, liberalization of international and domestic trade, and the changing allocation means of land resources and capital (Mittal and Kashyap, 2015; Müller et al., 2013; Su et al., 2011). Wei (2012) summarized that China's economic transition can be described from three aspects: globalization, decentralization and marketization. The liberalization of international trade makes China exposed to global competition. Under globalization, China attracted increasing oversea trade and investment and the demand for land consequently increased (Breslin, 2000). Decentralization grants the local government with much authority to allocate land resources (He and Zhu, 2007). In order to meet fiscal demand and obtain high economic growth as political achievements, the local governments were fancy of developing land market and approving industrial development zones (Wei and Leung, 2005; Su et al., 2014d). The increasing economic incentives encouraged dramatic urban sprawl. Marketization stimulates urban sprawl from two aspects. For one thing, demand for land was increased by the boom of private enterprises and industrialization (Chen et al., 2014; Gao et al., 2014). For another, supply of land was also increased by the development of urban land market (Ping, 2011).

Many cases have evidenced that agricultural landscape patterns would change significantly in the context of transition. For example, Long et al. (2009) reported that number of agricultural patches became higher and the largest patch area became lower in Su-Xi-Chang during China's economic transition. Brown and Schulte (2011) discovered an overall decrease in agricultural landscape diversity in Iowa over time. Conversely, Arvor et al. (2012) found increased agricultural diversity under transition. Su et al.