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New technical framework for assessing the spatial pattern of land development in Yunnan Province, China: A "production-life-ecology" perspective

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ABSTRACT

With the global accelerated pace of industrialization and urbanization, the state of disorder in land development has become the primary problem affecting sustainable and coordinated development in China. This study proposes a new technical framework to support the assessment of the spatial pattern of land development from a "production-life-ecology" perspective. The objective of our study was to develop a comprehensive assessment methodology by clarifying the functions of land and establishing a comprehensive index system that includes a total of 29 indicators. This framework can produce realistic and reliable patterns of land development because it synthetically takes formative environmental, social, and economic indicators into account while also considering the impact of human behaviors such as travel flow and economic flow on spatial land patterns. This research conducts a case study on the spatial pattern of land development in Yunnan Province of China in 2015, finding that the land development occurs in a scattered production-function pattern of one core, five groups, and coupled pairs of urban collaboration, a polycentric life-function pattern represented by radial concentric-ringed zones, and an aggregated ecology-function pattern with high values in the west and low values in the east. The proposed technical framework of pattern assessment can provide an effective reference for governments to improve the planning and development of land resources.

1. Introduction

With the growing pace of worldwide socioeconomic development, industrialization, and urbanization, problems related to global population growth, resource shortage, environmental pollution, and ecological degradation have become increasingly serious (Foley et al., 2005; Pauleit & Duhme, 2000). Because of these problems, a severe conflict has arisen between humankind and land resources, since the demands for land use are invariably greater than the available resources (Ozcan, Cetin, & Diker, 2003). Land is the most basic natural resource upon which humans depend for their lives and development, and land use efficiency and land ecosystems are both significantly affected by degradation (Costanza, D'Arge, & Groot, 1997; Foley et al., 2005; Kroll & Haase, 2010). This supply-demand gap has become a serious challenge for sustainable socioeconomic development (Hall, Perez, & Leclerc, 2000, pp. 18–33).

The spatial pattern of land development in China has changed dramatically with the process of rural-urban migration (Chang & Brada, 2006); natural areas have continued to shrink, and agricultural land has experienced a distinct structural adjustment (Dang, Xu, & Tang, 2015; Fan, Tao, & Ren, 2010; Zhou, Xu, & Wang, 2015). Research for the rational design of the spatial patterns of land development in order to

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support population growth, intensive economic activities, and the protection of ecologically fragile and environmentally damaged regions has become an urgent and indispensable challenge (Hananel, 2013; Long, Liu, & Hou, 2014). Studies on spatial patterns of land development have garnered considerable attention from policymakers and scholars, and the body of research is vast (Estoque & Murayama, 2013; Long, Gu, & Han, 2012; Rugkhapan, 2016). The related studies cover land suitability evaluation (Abdelrahman, Natarajan, & Hegde, 2016; Bathrellos, Gaki-Papanastassiou, Skilodimou, Papanastassiou, & Chousianitis, 2012; Thapa & Murayama, 2008; Xu & Zhang, 2013), land resource carrying capacity evaluation (Darnhofer, Fairweather, & Moller, 2010; Gomiero, Pimentel, & Maurizio, 2011; Zhou & Fan, 2015), and ecosystem service value evaluation (Estoque & Murayama, 2013, 2015; Sohel, Mukul, & Burkhard, 2015), among other topics. Most scholars focus on single or composite functions of land, but the diversity of social needs and land use demand an understanding of a more comprehensive functional system (Zhou et al., 2015). Some scholars have studied the classification system of land function and quantitative identification method (Fan et al., 2010; Huang, Lin, & Qi, 2017; Li & Fang, 2016; Zhang, Xu, & Zhu, 2015), including such divisions as urban and rural space in cities, towns, and rural areas (Li & Fang, 2016), and functions such as industrial development, tourist attractions, cultural landscapes (Huang et al., 2017), and so on. In addition, the Chinese government has also proposed the categorization of production space, residential space, and ecological space (Hu, 2012). However, there is still no unified standard for the division of land functions, and the study of spatial patterns of different land functions is not complex enough. In addition, the data used in research are mainly static, such as social and economic statistics and land use data (Dang et al., 2015; Sarzynski, Galster, & Stack, 2014; Wang, Liu, & Ma, 2010). These studies lack a consideration of human activity, even though the spatial pattern of land development is closely related to human behavior (Wu et al., 2014; Xu, Grumbine, & Beckschäfer, 2014).

Therefore, we propose a new technical framework to support the assessment of the spatial pattern of land development. This framework classifies land functions into three groups: the production function, which refers to that the land serves as the object of labor for direct production, or that land is used as a medium for the conduction of social production (Rugkhapan, 2016; Zhou, Li, & Li, 2016); the life function, which refers to the different types of material and spiritual support functions provided by land in the process of human life and development (Wang, Shen, & Tang, 2013; Zhang et al., 2015); and the ecology function, which is formed by ecosystems and ecological processes, and supporting the natural conditions for human existence (Grêt-Regamey, Altwegg, & Sirén, 2017; Xu, You, & Li, 2016) (hereafter referred to as “production-life-ecology”). This framework comprehensively and objectively considers factors affecting the spatial pattern of land from a “production-life-ecology” perspective, and it also considers the influence of human behavior on the spatial pattern of land by using dynamic data (referred to here as Internet big data). This framework can provide an effective reference for governments in urban planning and land management.

2. Study area

Yunnan Province is located along the southwestern border of China between 97°32′39″–106°11′47″ East and 21°8′32 ″–29°15′8″ North (Fig. 1). It is an inland plateau and mountainous province; it has a complex terrain, and significant elevation variation (Qiu & Yang, 2016). Although it has a relatively large amount of land resources, there are many land use constraints that make the spatial pattern of land development in Yunnan Province unreasonable. Additionally, the land resources have not been fully utilized, which affects the socioeconomic development of the province to a certain extent. First, the mountainous regions of the province cover about 84% of its land area, plateaus cover about 10%, and basins cover about 6%. Land with a slope of greater than 25° covers nearly 40% of the province's total area, meaning that the land resources that are suitable for construction or farming are insufficient (Li, Yu, Yao, Chen, & Li, 2016). Next, geological disasters and soil erosion are severe in Yunnan Province, and there are as many as 200,000 potential points for geological hazards such as rock falls, landslides, and mudslides, making it one of China's provinces with the highest geological disaster frequency. Finally, as a result of the influence of the complexity of Yunnan's terrain, various types of land use in Yunnan Province are extremely dispersed, and their structure and distribution are unreasonable. As such, land use in the province is diversified and complex.

The production level in Yunnan Province is poor. It does not emphasize ecological protection, causing regional degradation of the ecological environment and the uncoordinated development of production and ecology. The conflict between production, human living and ecology has become serious. Therefore, it is urgent and necessary to conduct research on the spatial pattern of land development in Yunnan Province from the perspective of a “production-life-ecology” function.

3. Technical framework

This study proposes a new technical framework suitable for research on the assessment of the spatial pattern of land development (Fig. 2). This framework includes a “production-life-ecology” assessment model using static geographical data such as China geography census data, along with a spatial interaction method using dynamic data such as Internet data. The spatial patterns of land development are preliminarily obtained by the “production-life-ecology” assessment model, and then optimized using the results of spatial interaction. When combining the assessment results of the production/life function with the results of the spatial analysis, we first superimpose the space analysis results into a preliminary space pattern of the production/life function to determine common areas. On this basis, we refer to a government spatial planning document (The Yunnan Province Principal Functional Regions Plan), and the results of the spatial analysis of the above comprehensive analysis are presented in the form of boxes or circles on the final spatial analysis chart. With this combination of static geographic data and dynamic Internet data, the final patterns are believed to be more realistic and reliable than those do not refer to such spatial interaction.

The preliminary spatial patterns of land development are first calculated and analyzed at the county level. In China, each county can be regarded as both an administrative and an economic region. Then, to support the macro-analysis of the spatial patterns for the whole province, the kriging interpolation method is applied, generating full-cover preliminary patterns of land development in Yunnan Province at the spatial resolution of 500 m; the preliminary patterns are optimized with the results of the spatial interaction to obtain the final spatial patterns of land development in Yunnan Province. In this study, the county-level vector datasets are collected, processed and analyzed with the assistance of ESRI ArcGIS and its Spatial Analyst tool.

3.1. Static data

3.1.1. China geography census data

In 2012, in order to gain a comprehensive understanding of China's current geographical conditions and meet the needs of social and economic development and ecological civilization construction, the State Council of China released a notification to conduct the First Survey of National Geographical Conditions; thus, the first China Geography Census (CGC) was conducted from 2013 to 2015 (Wei et al., 2017). The CGC had two primary goals: (1) to survey the attributes of the natural geographical features, including the type, site, scope, area of topography, vegetation cover, water area, desert, open ground, and so on; and (2) to survey the attributes of the human geographical features, including the classification, site, and scope of transportation networks,