Ecological Indicators 46 (2014) 477–486

Contents lists available at ScienceDirect

Ecological Indicators

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

Peri-urban vegetated landscape pattern changes in relation to socioeconomic development

Shiliang Su[a,b,c,*], Yaping Wang[a], Fanghan Luo[a], Gengchen Mai[a], Jian Pu[a]

[a] School of Resource and Environmental Sciences, Wuhan University, Wuhan, China
[b] Key Laboratory of Geographical Information Systems, Ministry of Education, Wuhan University, Wuhan, China
[c] Key Laboratory of Digital Mapping and Land Information Application Engineering, National Administration of Surveying, Mapping and Geoinformation, Wuhan University, Wuhan, China

ARTICLE INFO

Article history:
Received 29 January 2014
Received in revised form 18 June 2014
Accepted 25 June 2014

Keywords:
Vegetated landscape patterns
Landscape metrics
Socioeconomic indicators
Peri-urbanization
Remote sensing

ABSTRACT

Peri-urban vegetation, which delivers a diversity of fundamental services, sustains increasing pressures from human activities. Characterizing the socioeconomic drivers of vegetated landscape pattern changes can inform ecological management. Vegetated landscape pattern changes, (including paddy, dryland, woodland, forest, and perennial plantations) in Tiaoxi watershed (China) between 1985 and 2009, were characterized using a set of landscape metrics. Their relationships with socioeconomic development were quantified by multivariable regression. Results showed that Tiaoxi watershed experienced rapid socioeconomic development based on a set of indicators (demography, economy, and social activities). Vegetated landscapes were less abundant and connected, and became more irregular, fragmented, and diverse at landscape level. At class level, increasing fragmentation and isolation were identified for all vegetated landscape types. Paddy, dryland, and forest decreased in area and aggregation, while woodland and perennial plantations presented opposite trends. Socioeconomic drivers of vegetated landscapes pattern changes differed with metrics and with vegetated landscape types. Generally, population growth, road construction, income increase, and tertiary industry development were the major drivers. The identified socioeconomic drivers differed from those for urban areas in previous related report. The inconsistence could be attributed to the different socioeconomic conditions and their interactions with land use practice between urban and peri-urban areas. This study contributed to the identification of key socioeconomic indicators influencing vegetated landscape pattern changes in peri-urban regions.

1. Introduction

Urbanization has been the most powerful driver of world development in recent decades. Particular emphasis was put on metropolitan cores, since these places experienced continuously dramatic growth. Nevertheless, spatial patterns of urbanization are changing. Urban expansion, concentrates in former metropolitan peripheries, progressively emerges into rural areas and small towns (Aguilar and Ward, 2003). The dispersed urban expansion gives birth to a wide urban–rural interaction zone with increasingly diffuse limits between rural and urban characters (Aguilar, 2008). The transition zone, where rural activities are juxtaposed with urban activities, is labeled as "peri-urban" in literature (Douglas, 2006). Since peri-urban regions present unique characteristics of socioeconomics and ecology, the rapid urban land growth would influence ecosystems' structure and functions (Huang et al., 2009). Ecological consequences of peri-urbanization cannot be ignored (Douglas, 2006), because peri-urbanization would possibly pose greater impacts than the land use that it replaces (Kearney and Macleod, 2006). However, both urban and rural administrations often ignore the ecological changes associated with socioeconomic development in peri-urban areas (Huang et al., 2009).

Peri-urban regions are always rich in vegetation resources, including all cultivated and spontaneous vegetated-cover types, such as woodland, cropland, grassland, and forest. Peri-urban vegetation delivers a diversity of ecological and social services, varying from climate regulation, soil erosion control, and biodiversity maintenance to water quality amelioration, air pollutants absorption, and recreational opportunity supply (Douglas, 2006; Pert et al., 2012; Wagrowski and Hites, 1997). Being sensitive to human activities, peri-urban vegetation has been sustaining increasing pressures (Bajocco et al., 2012; Delm and Gulinck, 2011; Salvati and Zitti, 2012; Tang et al., 2012). Characterizing the socioeconomic

* Corresponding author at: School of Resource and Environmental Sciences, Wuhan University, No. 129 Luoyv Road, Wuhan, China.
E-mail address: shiliangsu@163.com (S. Su).

http://dx.doi.org/10.1016/j.ecolind.2014.06.044

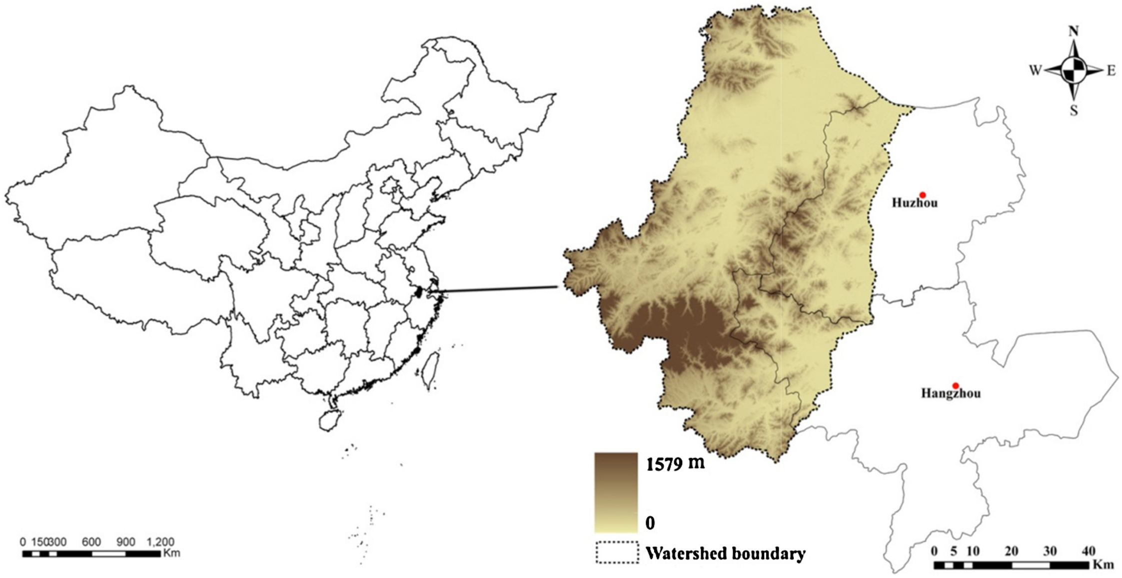

Fig. 1. Location of Tiaoxi watershed within the urban–rural interaction zone of Hangzhou City and Huzhou City, eastern coastal China.

drivers of vegetation dynamic changes should therefore provide critical references for resource conservation and ecological management in peri-urban regions.

Inventory of peri-urban vegetation is on the rise, with the help of remote sensing. Majority of previous studies focused on the spatiotemporal distribution of vegetation cover, areal changes, and species composition (Delm and Gulinck, 2011; Miller, 2012; Tang et al., 2012). Few efforts have been spared on multi-temporal monitoring of structures and functions of vegetated ecosystems, given the high costs of field survey and scarcity of long-term observation data. Enough evidence demonstrates that landscape patterns significantly influence a variety of ecological processes and functions (Leitão and Ahern, 2002; Turner et al., 2007; Weng, 2007), and can be used to indicate the quantitative and qualitative changes of natural resources in an indirect way (Weng, 2007; Su et al., 2012). Compared to field trips, landscape ecological approach can offer overall perceptions of landscape characteristics and can be easily used for management implications (Fernandes et al., 2011; Mairota et al., 2013; Sowińska-Świerkosz and Soszyński, 2014). However, rather few studies have applied landscape ecological approach to investigate peri-urban vegetation dynamics. In addition, the socioeconomic factors governing peri-urban vegetated landscape pattern changes remain poorly understood.

Considering the above mentioned shortcomings, this paper intends to characterize the changes of peri-urban vegetated landscape patterns under rapid socioeconomic development. Data were collected for the Tiaoxi watershed, a typical peri-urban region in the Chinese eastern coast. Our objectives are to: (1) analyze vegetated landscape pattern changes in Tiaoxi watershed between 1985 and 2009, (2) compare the landscape characteristics among different vegetated landscape types, and (3) quantify the relationships between vegetated landscape pattern changes and socioeconomic development.

2. Methodology and data

2.1. Study area

The Tiaoxi watershed lies within the urban–rural interaction zone of Hangzhou City and Huzhou City, two of the most urbanizing megacities in the Chinese eastern coast (Fig. 1). Covering about 6000 km^2, it extends from 119°14′E to 120°13′E, and from 30°07′N to 31°11′N. With a subtropical monsoon climate, annual mean temperature reaches 17.5 °C and rainfall amounts to 1100 mm. Tiaoxi watershed is superior in ecological quality with high vegetation coverage. Since the 1980s, Hangzhou City and Huzhou City have been experiencing rapid urbanization, which stimulated the socioeconomic development in their surrounding peri-urban areas. Such rapid socioeconomic development spurred intensive built-up land expansion in Tiaoxi watershed (Su et al., 2011). Vegetated area has been gradually depleted and vegetated landscape pattern would be transformed. This watershed not only exemplifies rapid socioeconomic development mirrored in many peri-urban areas worldwide, but also represents the ecological degradation of vegetation resources faced by developing countries under urbanization. The case of Tiaoxi watershed can therefore be typically relied on to analyze peri-urban vegetated landscape pattern changes in relation to socioeconomic development.

2.2. Images processing

The primary land use data was from Su et al. (2014a). Remotely sensed data source included Landsat Thematic Mapper (TM), Landsat Enhanced Thematic Mapper (ETM+), and China–Brazil Earth Resources Satellite (CBERS). TM images were collected for years of 1985, 1994, 2005, and 2009; ETM+ images were collected for years of 1999, 2000, 2001, 2002, and 2003; CBERS images were collected for years of 2004, 2006, and 2007. Pre-processing details were described in Su et al. (2014a). Considering the dominant vegetated landscape elements and image resolution, five vegetated landscape types (paddy, dryland, sparse woodland, dense forest, perennial plantations) were visually interpreted from remotely sensed images. We first interpreted the 2009 vegetated landscape type map, and assessed its accuracy in reference to 80 points collected in field trips. The overall accuracy reached 91.7%, and Kappa index was 90.1. Then, it was used as reference for the other years. The final output is a vector dataset. We only displayed four years of vegetated landscape type maps (Fig. 2), to give the readers the possibility to get an overview.

2.3. Selection of landscape metrics

Metric analysis provides an effective way for quantitative description of landscape patterns (Leitão and Ahern, 2002; Lang