Ecological Indicators 89 (2018) 336–347

Contents lists available at ScienceDirect

Ecological Indicators

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

Comparison of Intensity Analysis and the land use dynamic degrees to measure land changes outside versus inside the coastal zone of Longhai, China

Boqiang Huang[a], Jinliang Huang[a,*], Robert Gilmore Pontius Jr.[b], Zhenshun Tu[c,d]

[a] Coastal and Ocean Management Institute, Xiamen University, 361005, China
[b] Graduate School of Geography, Clark University, Worcester, MA, USA
[c] Fujian Institute of Oceanography, Xiamen 361013, China
[d] Fujian Provincial Key Laboratory of Coast and Island Management Technology Study, Xiamen 361013, China

ARTICLE INFO

Keywords:
Land change
Urbanization
Intensity Analysis
Land use dynamic degree
Pattern
Coastal area

ABSTRACT

We compare two popular methods to quantify temporal change among categories: 1) Intensity Analysis and 2) the land use dynamic degrees. We apply the methods to measure land change both outside and inside the coastal zone of Longhai, which is a typical county-level coastal city in Southeast China. The maps show eight categories at four time points: 1986, 1996, 2002, and 2010. Intensity Analysis shows graphically the size and the intensity of changes at three increasingly detailed hierarchical levels in a manner that facilitates interpretation. In contrast, the comprehensive land use dynamic degree (CLUDD) has no practical interpretation because the CLUDD is the sum of loss intensities of categories that have different sizes. The single land use dynamic degree is the annual net change as a percentage of the initial size of the category, which offers limited information because the single degree: 1) fails to reveal the sizes of the category's loss and gain, 2) does not indicate how each category contributes to total change, 3) is sensitive to the category's initial size, and 4) reveals neither the size of the category's annual net change nor the size of the category's initial size.

1. Introduction

1.1. Measurements of land change

Land change in China has drawn much attention because Chinese cities are undergoing rapid intensive anthropogenic development. The remarkable land changes, especially urbanization, that have occurred in coastal China during recent decades have been extensively documented (Liu et al., 2014a; Schneider and Mertes, 2014; Tian, 2015). Several scholars have used various methods to measure land changes. For example, Liu et al. (2013) developed an index system to evaluate the current state of rural area development at the county level in eastern coastal China. Chen et al. (2014) used an urban expansion rate and an intensity index to measure urban expansion patterns in Shenzhen and Dongguan. Quan et al. (2015) used the single and comprehensive land use dynamic degrees to evaluate urban expansion in a small city, Quanzhou, China. Deng et al. (2015) developed an econometric model to estimate the impacts of urbanization on cultivated land in eastern coastal China. He et al. (2017) developed a coupling coordination degree model to examine the relationship between urbanization and the eco-environment in Shanghai. Wan et al. (2015) used land-change amplitudes, a landscape pattern index, and a transition matrix to compare the Honghe National Nature Reserve versus the surrounding region. Several of these methods examine detailed patterns that are so complex or subtle that they can be difficult to interpret, without knowing first some basic metrics of land change. Two particular methods have become popular as a starting point to quantify land change. These two methods are: Intensity Analysis (Aldwaik and Pontius, 2012) and the land use dynamic degrees (Liu et al., 2014a). Our paper compares Intensity Analysis to the land use dynamic degrees in both theory and practice, to gain insight into each framework's abilities and limitations to describe change. We illustrate the concepts with an application to a case study that compares land change during three time intervals in two zones of Longhai, China.

Intensity Analysis is a framework that organizes measurements of changes according to three hierarchical levels, each with its own interpretation (Aldwaik and Pontius, 2012). Authors have applied Intensity Analysis to gain insight into processes of land changes in many countries including Ghana, Australia, Colombia, Japan, and China (Braimoh, 2006; Versace et al., 2008; Romero-Ruiz et al., 2012;

* Corresponding author.
E-mail address: jlhuang@xmu.edu.cn (J. Huang).

https://doi.org/10.1016/j.ecolind.2017.12.057
Received 10 August 2017; Received in revised form 22 December 2017; Accepted 24 December 2017
1470-160X/ © 2017 Elsevier Ltd. All rights reserved.

Shoyama and Braimoh, 2011; Huang et al., 2012; Zhou et al., 2014). Intensity Analysis reveals patterns, which can then be linked to the underlying processes. Intensity Analysis can assess the evidence for a particular hypothesized process of change and can help to develop new hypotheses concerning processes of change (Pontius et al., 2013). For example, Alo and Pontius (2008) used Intensity Analysis to quantify land transitions both inside and outside a protected area in Ghana, thereby giving evidence to the hypothesis that logging is the main cause of the loss of closed forest inside the protected areas whereas farming is the main cause of the loss of closed forest outside the protected areas.

The comprehensive land use dynamic degree (CLUDD) and the single land use dynamic degree constitute another popular framework to analyse temporal change among land categories. Liu et al. (2002, 2003) introduced the degrees in Chinese and English, which have been cited more than 1180 times according to Google Scholar as of 2017. However, readers have construed various possible ways to compute the degrees due to confusing mathematical notation. Despite the confusion, the degrees have become extremely popular as authors frequently misinterpret the degrees to compare cases that have various spatial and temporal extents (Pontius et al., 2017). The CLUDD combines measurements across all categories, while the single land use dynamic degree assesses annual net change for each single category. The Materials and Methods section defines the metrics of Intensity Analysis and the land use dynamic degrees, and illustrates the calculations with an application to Longhai, China.

1.2. Case study

Longhai is a county-level coastal city in Fujian province in Southeast China, near the Taiwan Strait. Longhai is rich in natural and cultural resources due to its unique geography and history. Natural conditions, such as shelter from wind, low siltation and appropriate water depth, make the coast an excellent choice for ports. Longhai is also famous for its rich and various kinds of living marine resources. There are more than 200 fish species. The area of mangrove reserve in Longhai is five square kilometres, distributed mostly on the coast of the South River estuary and on Zini & Haimen Islands, making an indispensable contribution to protection of the coastal ecosystem. Woodland and farmland protection areas are of great environmental and economic concern. Longhai has traditional agriculture & aquaculture activities and modern economic development zones. However, it has not been clear how to manage the trade-off between environmental protection and economic development during the most recent three decades, especially concerning land changes inside the coastal zone.

Fig. 1 shows Longhai city situated as a county-level coastal city in Fujian province in Southeast China, covering an area of 8057 square kilometres. The “inside coastal zone” is the 1346 square kilometre area between the provincial road and the sea administrative boundary. The “outside coastal zone” is the 6711 square kilometre area that is not inside the coastal zone. There is an obvious distinction between the two zones in terms of physical factors. Outside the coastal zone is mountainous where more than 80% of the area has a topographic slope in excess of 25 °, but slope in excess of 25 ° occupies only 6% of the area inside the coastal zone. Both of the zones face degradation of Woodland areas. Both of the zones have been undergoing rapid land change and also have been stressed by human activities as a result of economic development.

2. Materials and methods

2.1. Data

Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper plus (ETM+) images at 1986, 1996, 2002 and 2010 serve as the data. Table 1 describes the satellite images. These Landsat images are from the Center for Earth Observation and Digital Earth (CEODE), Chinese Academy of Sciences (http://cs.rsgs.ac.cn/cs_cn/) and the United States Geological Survey (USGS) (http://eros.usgs.gov/).

We performed several steps to create a consistent time series of maps. First, we registered the images geometrically. The 2010 image was registered to topographic maps using features such as road intersections and stream confluences that were clearly visible. The 2010 image was georeferenced to the UTM-WGS 1984 map projection, Beijing 1954 coordinate system, Central Meridian 117 N. Then, this 2010 image was used as the reference to rectify the images for 1986, 1996, and 2002. A first-order polynomial nearest neighbor algorithm with 32 ground control points re-sampled the images so that the root mean square errors were less than half a pixel. All the images were resampled to a 30 m resolution.

We then applied hierarchical classification to derive the land category map for 2010. ENVI software was used to generate the classification thresholds. We used linear stretching based on spectral characteristics to separate the categories. Afterwards, we performed unsupervised classification for each layer by using the Iterative Self Organizing Data Analysis Technique Algorithm (ISODATA). This generated 150 clusters for each layer. We assigned every cluster to one of eight land categories based on visual interpretation of Google Earth images, GIS data and information we collected during field trips. Manual on-screen digitizing was used to edit the classified maps (Yang and Liu, 2005). We created a single map for 2010 by mosaicking using ERDAS Imagine 9.3 software.

We used the 2010 map to help classify each of preceding years in sequence. The process consisted of overlaying the map of 2010 on the 2002 image so we could use visual interpretation to group pixels with the same characteristics. We repeated this procedure for 1996 and 1986 to produce a sequence of land cover maps at 1986, 1996, 2002 and 2010. We then used post-classification comparison to detect categorical transitions by overlaying pairs of land cover maps from sequential time points using ERDAS. Each pair of time points generates a square contingency table.

Intensity Analysis and the land use dynamic degrees use square contingency tables as inputs for the mathematical computations. Table 2 gives the mathematical notation for Intensity Analysis and the land use dynamic degrees.

2.2. Intensity Analysis

Intensity Analysis is a hierarchical framework that has three levels of analysis, where each increasing level explores increasingly detailed patterns, given the preceding level (Aldwaik and Pontius, 2012, 2013; Pontius et al., 2013). The first level is the time interval level, which examines how the annual change percentage S_t during each time interval $[Y_t, Y_{t+1}]$ compares to a uniform annual change percentage U during the temporal extent $[Y_1, Y_T]$. If $S_t < U$, then S_t is slow, meaning the time interval $[Y_t, Y_{t+1}]$ experiences change slower than if the changes during all time intervals were distributed uniformly during the temporal extent $[Y_1, Y_T]$. If $S_t > U$, then S_t is fast, meaning the time interval $[Y_t, Y_{t+1}]$ experiences change faster than if the changes during all time intervals were distributed uniformly during the temporal extent $[Y_1, Y_T]$. Eq. (1) gives S_t and Eq. (2) gives U, both of which assume the spatial extent is identical at each time point, as is the case in our application; therefore it does not matter which time t the summations in the denominators use.

$$S_t = \frac{(\text{size of change during } [Y_t, Y_{t+1}])100\%}{(\text{size of spatial extent})(\text{duration of } [Y_t, Y_{t+1}])} = \frac{\left\{\sum_{i=1}^{J}\left[\left(\sum_{j=1}^{J} C_{tij}\right) - C_{tii}\right]\right\}100\%}{\left[\sum_{i=1}^{J}\left(\sum_{j=1}^{J} C_{tij}\right)\right](Y_{t+1} - Y_t)} \quad (1)$$

Download English Version:

https://daneshyari.com/en/article/8845473

Download Persian Version:

https://daneshyari.com/article/8845473

Daneshyari.com