Tourism-Led Land-Use Changes and their Environmental Effects in the Southern Coastal Region of Hainan Island, China

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ABSTRACT


Tourism has been often considered as an effective way to promote economic growth for coastal areas in developing countries. As the most important tourist destination and the largest Special Economic Zone in China, Hainan chose tourism-led development and achieved rapid economic growth. This paper analyzes land-use changes driven by tourism-led development and their environmental effects during a period of time from 1991 to 2007 in Sanya City, southern coastal region of Hainan Island. High-resolution remote sensing and detailed socioeconomic data were used in the study. Based on a combination of remote sensing and geographic information systems methods, a matrix of land-use change was constructed to identify land-use changes between 1991 and 2007. The outcomes indicate that the changes from farmland to construction land and from forestland to orchard are the main transformation types. From 1991 to 2007, farmland and forestland decreased by 15% and 29% respectively; on the contrary, construction land and orchard increased by 242% and 258%. The transformation from farmland to construction land mainly occurred in plains along the coastline, while the changes from forestland to orchard mainly occurred in middle platform areas. Booming tourism not only led to the increased demand for tourism infrastructure and rapid urban expansion, but also boosted the demand for tropical fruit products. Tourism-led development restructured the land-use pattern dramatically, which caused construction land increase and farmland loss, and forest was converted to orchard, driven by the high speed of market demand of fruit products. Tourism-led development destroyed Sanya’s tourism resources and dissipated its initial advantage to some extent, which will hinder the sustainable development of tourism. Finally, some suggestions are given to coordinate the tourism-led land development in coastal regions.

ADDITIONAL INDEX WORDS: Land-use changes, tourism-led development, environmental effects, southern coastal region of Hainan Island.

INTRODUCTION

Since the early 1980s, the unprecedented combination of economic growth and population increase has led to dramatic land transformation in China (Lin and Ho, 2003; Liu et al., 2010; Xu, 2004) in various forms, including urban sprawl, increased built-up area, and farmland loss (Lin and Ho, 2005; Xie et al., 2005). The rapid land-use change is receiving increasing attention from policymakers and scholars, at home and internationally. The existing land-use change literature has discussed the spatial and temporal patterns and the driving forces for the whole China or particular regions, and it has also addressed the issue of the land-use transformation on environment (Liu, Wang, and Long, 2008; Long et al., 2009; Wu et al., 2008; Xu, 2004). However, the land-use transformation is a product of the changes in the broader socioeconomic system, namely, the pattern of land-use transformation could be largely influenced by the development of industrial economies. A considerable volume of work relates to the manufacture-led land-use change, while relatively little special attention has been paid to the service industry-dominated land-use change. A major aim of this study is to start to fill this gap by examining the land-use changes driven by tourism-led economic growth and their environmental effects, taking the largest tourist destination and Special Economic Zone in China, Hainan Island, as a case study.

Tourism, one of the main economic activities worldwide, is also closely related to land use and land cover. Many developing countries in the tropics have relied on tourism to generate economic wealth and job opportunities to diversify their economy as well (Gössling, 2001; Rico-Amoros, Olcina-Cantos, and Sauri, 2009). As a kind of human activity, tourism development, involving accommodation establishments, transport infrastructure, leisure activities, etc., contributes to changes in land cover and land use dramatically (Gössling, 2002). For example, most forest loss in the Angkor Basin,
Cambodia, was due in part to charcoal production to serve the tourist industry, and also conversion to permanent agriculture (Gaughan, Binford, and Southworth, 2009). Construction in residential areas has proceeded in a disorderly fashion by developing tourism in the Lugu Lake area (Don, Yu, and Liu, 2008). The rapid emergence of mass tourism development in Turkey, encouraged without considering protection and sustainable use of natural and cultural resources, has resulted in serious problems in forest areas (Esbah et al., 2010; Kuvan, 2005). Remote sensing (RS) and geographic information systems (GIS) have been accepted as powerful and effective tools for detecting land-use patterns and changes therein (Fazal, 2000; Lambin, 1997). Usually, characterization of land use requires the integration of ground-based surveys and census data with remotely sensed data, and spatially explicit land-use information can be detected by RS. There are widely used approaches for change detection and statistical analysis, which contribute to the discovery of the structural variation among different land-cover patterns and to diagnosis of land-use changes based on time series of socioeconomic data (Kraussmann et al., 2003; Liu, Wang, and Long, 2008; Xie et al., 2005).

With the further development of the reform, tourism has been a popular industry in Chinese coastal regions. Tourism development has led to other patterns of land transformation, and has also brought about many environmental issues. Hainan Island is located in the South China Sea and is separated from the Chinese mainland by the Qiongzhou Strait. In 1988, Hainan was upgraded to the provincial level and given the status of Special Economic Zone (SEZ) by the State Council of the People’s Republic of China. The project of building an International Tourist Island (ITI) was approved by the State Council of the People’s Republic of China on December 31, 2009. Sanya is the most popular tourist destination and the second largest city of Hainan Province, and it is located in the southern-most Hainan Island. Accompanying the tourism-led development, land use and land cover have changed remarkably in Sanya. The objective of this paper is thus to describe land-use patterns and changes of Sanya from 1991 to 2007, and also to examine the relation between the tourism development and the spatial and temporal land-use dynamics, and finally to explore how tourism-led land-use changes influence their environment. This paper tries to better understand the dynamics of the tourism-dominated land-use transformation in southern coastal China, which will hopefully be useful for rational policymaking for sustainable land management in coastal regions.

MATERIALS AND METHODS

Study Area

Sanya is one of the (if not the) most famous tourist cities in the tropical coastal region of South China, and it is located at 108°56’30”-109°48’28” E, 18°09’34”-18°37’27” N. Sanya covers 1864 km², with terrace-shaped landforms of plain, platform, and hilly terrain from south to north. The plain, platform, and hilly terrains account for about 23%, 18.4%, and 59%, respectively. Sanya is dominated by a tropical monsoon climate, with a mean daily temperature of 26.2°C, a mean annual rainfall of 1608.8 mm, and a mean annual sunshine period of 2222.9 h, which together are beneficial for tropical agriculture and also tropical tourism development. There are 19 bays along its coastline, which is about 209 km in length; Yalong Bay, Yulin Bay, Sanya Bay, Haitang Bay, Hongtang Bay, and Yazhou Bay are the most famous ones among them (see Figures 1 and 2). They are certainly valuable natural resources for the takeoff of the tourism industry. After Hainan Province was granted the SEZ status, Sanya enjoyed lot of preferential investment policies, and it has already become one of the leading tourist destinations in China and Southeast Asia.

Data Resources and Processing

Land-use data, topographic maps, and socioeconomic statistical data were collected. Two historical Landsat TM (Thematic Mapper) satellite images (made in July 1991 and October 2007, respectively) were obtained from the Scientific Database of the Chinese Academy of Sciences. A topographic map of 1:50,000 scale was provided by the Land and Resources Bureau of Sanya. In November 2009, a field survey including 82 points was carried out by using a global positioning system to identify present land-use types and inquire into land-use histories. These points were evenly distributed in the study area, and land-use types and transportation conditions were taken by and large into consideration. At least 17 well-distributed ground control points (GCPs) were selected according to the topographic map, and they were used in the image rectification process. The root mean square error (RMSE) was less than 1 pixel. A first-order polynomial fit was applied, and all the data were resampled to a spatial resolution of 30 m using nearest neighbor method. In order to reinforce visual interpretability of images, a color composite (Landsat TM bands 4, 5, and 3) was prepared, and its contrast was stretched using a Gaussian distribution function. The 3 × 3 high-pass filter was applied to the color composite to further enhance visual interpretation of linear features, e.g., rivers and vegetation features.

In addition, some time-series socioeconomic data from 1991 to 2007 were collected from the local Statistical Bureau (SSB,
1992–2008), in order to analyze the relationship between tourism development and land-use changes in Sanya.

**Study Methods**

A classification system of seven land-use classes was applied to the Landsat TM data, including farmland, forested land, grassland, water body, construction land, orchard, and unused land. Farmland is defined as all cultivated lands for crops, forested land is the land for growing trees, including arbor and shrubs for forestry use, grassland includes native grassland and tame pasture, water body contains stream and rivers, lakes, reservoirs, and ponds, construction land consists of urban areas, rural settlements, and others such as roads and airports, orchard is composed of tea-garden, rubber plantation, mango, and nurseries, and unused land refers to land that is not put into practical use or that is difficult to use. Seven training areas were established according to more than 100 field sampling points and the first land-use investigation map made by Land and Resources Bureau of Sanya in 1996. Then, the two images were interpreted by the method of supervised classification using a maximum likelihood classifier (MLC); visual interpretation involved the use of image characteristics such as texture, pattern, and color to translate image into land use. A $3 \times 3$ majority-neighborhood filter was used to adjust the classified images.

Two periods of gridded land-use maps were mainly used to detect the internal variations of land-use changes in Sanya during the period of time under study. A change matrix was constructed by overlay analysis. Eighteen buffer zones from the coastline to the north were built at an interval of 2 km. They were used to examine the spatial distribution characteristics of land-use types including farmland, forested land, construction land, and orchard area in 18 buffers is depicted in Figure 5. During the period of 1991–2007, the proportion of farmland decreased dramatically from buffer 1 to buffer 5, and, accordingly, construction land increased considerably. The proportion of forestland reduced notably from buffer 2 to buffer 5, and the regions of buffer 2 to buffer 8 changed most remarkably. It can be inferred that the transformation of farmland to construction land mainly occurred in buffer 1 to buffer 5, forestland to orchard transition

**RESULTS**

**Temporal and Spatial Patterns of Land-Use Changes**

Land-use changed significantly over the whole period average in Sanya (Figure 4), and its characteristics can be summarized as following: (1) Farmland decreased 4180 ha (15%) in total, 52% of which was converted into construction land. Over 80% of farmland is distributed in the plains area along the coastline; however, most tourism infrastructures are located in this area. The conversion of farmland-to-construction land is mostly along the coastline. (2) The area of forested land shrank rapidly, mainly converted into orchard. Forestland decreased 36,851 ha (29%). There was 94% of deforested land converted into orchard, which are mostly distributed in gradual slope land close to water source areas, where it is suitable to plant mango, banana, areca, rubber plants for favorable irrigated conditions. Because of strict control of cultivated land loss, farmers have to deforest gradual slope land converted into orchard, which are mostly distributed in gradual slope land close to water source areas, where it is suitable to plant mango, banana, areca, and rubber plants for favorable irrigated conditions. (3) Both construction land and orchard grew rapidly, which increased by 10,927 ha (242%), and 33,389 ha (258%) respectively (Table 1). The area of construction land in 2007 was 3.4 times larger than that in 1991, and the area of orchard in 2007 was 3.6 times larger than that in 1991.

**The Changes of Main Land-Use Types**

To further examine the spatial patterns of land-use changes along the coastline, the proportion of main land-use types including farmland, forestland, construction land, and orchard area in 18 buffers is depicted in Figure 5. During the period of 1991–2007, the proportion of farmland decreased dramatically from buffer 1 to buffer 5, and, accordingly, construction land increased considerably. The proportion of forestland reduced notably from buffer 2 to buffer 5, while the proportion of orchard increased sharply, and the regions of buffer 4 to buffer 8 changed most remarkably. It can be inferred that the transformation of farmland to construction land mainly occurred in buffer 1 to buffer 5, forestland to orchard transition.
mainly occurred in buffer 4 to buffer 8, and there was no significant changes in buffer 13 to buffer 15.

Tourism-Led Development and Land-Use Changes

Depended on existing natural and cultural tourism resources, Sanya’s tourism development has received a great deal of attention since the 1980s (Wang and Liu, 2009). Tourism has been the leading industry of Sanya City. The number of tourist arrivals grew from 139.9 thousand in 1991 to 2.78 million in 2007 (SSB, 1992–2008). The use and conversion of land is central to tourism (Gössling, 2002). Three dominant paths of tourism-led development drove land-use changes in Sanya. These are detailed as follows:

Rapid increase of tourism infrastructures occupied large fertile farmland. As the number of tourists increased, the specialized infrastructures for the tourists, such as accommodation establishments, transportation, and leisure facilities, were built up along coastline. The number of international hotels for accepting foreign guests increased from 19 in 1991 to 161 in 2007, representing a rise from 1498 to 23,778 rooms. As a consequence, most fertile farmland along coastline was occupied. For example, through field investigation, we found that there were not more than six international hotels to the west of Phoenix International Airport along Sanya Bay in 2000. However, there were standing more than 20 international hotels in 2009. The buildings along Sanya Bay in 2002 and 2009 can be seen in Figure 6. In addition, because of the boom of rural tourism, a lot of small-budget hotels and family hotels were built up near the scenic spots in rural areas along coastline, which also led to farmland loss (Figure 4c).

Tourism-led urban expansion caused construction land increase and farmland loss. Both encouraged by tourism development and attracted by beautiful scenery and tropical climate, Sanya has been experiencing rapid tourism-led urbanization since 1990s. Urban population has increased from 89,692 to 265,466 over the period from 1991 to 2007. According to the data of Sanya’s sixth census in 2010, there were 201,000 residents who had immigrated from the mainland, mostly living in urban area, which represents 29.2% of the total resident population. Meanwhile, tourism real estate, built near scenic spots and along the coastline, has been a booming industry in Hainan Island, which has been sold to people outside the island for seasonal holiday use. Tourism real-estate development has accelerated the progress of urbanization in Sanya, and occupied large areas of farmland.

Tourism development has triggered the demand for tropical fruit in Sanya. Because of the increasing number of tourists,
the tropical fruit products have increased by a big margin, which in turn has caused the rapid rise in prices of the fruit products themselves. Driven by the high price of fruit products compared to traditional crops, deforestation is becoming more and more prevalent, because so much crop land also is being taken up for cultivating fruit products. The planting area of tropical fruit, including mango, banana, and areca nut, expanded from 5074 ha in 1991 to 9061 ha in 2007.

NDVI Change and its Spatial Patterns
There were 45,666 ha (24.5%) that had a positive value (>0) of NDVI in 1991, only 37,278 ha (20%) of which remained positive in 2007. From 1991 to 2007 (11,556 ha) 6.2% of the overall area had a significant NDVI decline (>0.5), while only 0.8% (1491 ha) had a significant NDVI increase (>0.5). The spatial concentration of NDVI decreased along the coastline and rivers, which were also the areas of farmland-to-construction land and forestland-to-orchard transition from 1991 to 2007 (Figure 7). It can be shown from the NDVI change and its spatial patterns that tourism development caused vegetation destruction along coastline, which resulted in ecological problems.

Coastal Environmental Consequences Caused by Tourism-Led Land-Use Changes
Tourism-led development has reshaped the land-use pattern of Sanya. As the tourism industry development in Sanya
largely depends on natural scenic resources, most of accommodation establishments were constructed in the vicinity of landscape resources and scattered along the coastline in Sanya (Figure 4), which has resulted in landscape fragmentation. At the same time, owing to the extension of tropical cropland area, orchards have occupied forestland patches, which has caused forestland to be more and more fragmented.

The high-speed expansion of the tourism industry caused rapid land-use changes in a short time in Sanya, which has brought about serious coastal ecological problems. Along the 209 km coastline, all bays except Yazhou Bay have been exploited for tourism development. For developing tourism projects, most of the sand embankment along the coastline was destroyed and replaced by tourism infrastructures and residential buildings, and about one third of the shelter forest along the coastline was damaged. The NDVI change and its spatial patterns can confirm the processes. Figure 8 shows the leaving roots of a coconut grove that was cut down for building tourism infrastructures (a), and the new asphalt road for tourism development directly connected to the sea (b).

Meanwhile, intensive human activities along the coastline have brought about pollution, which has seriously impacted inshore habitat. Many plants, such as psammolittoral organisms, coral reefs, mangroves, and seaweed, have been reduced. As a result, the functions of windbreak and keeping soil intact have been lost already in many places, especially in popular tourist destinations, which have caused exposure and vulnerability. Since the natural defenses are invalid, coastal erosion has become more and more common. According to the Chinese sea-level report in 2006, for Yalong Bay and Sanya Bay, coastal erosion has worsened and the coastline has retreated 1 to 2 m per year since 2002 (China’s State Oceanic Administration, 2006).

With the massive agricultural exploitation for planting tropical orchard in >25° slope land, soil erosion and vegetation degradation have been aggravated. Once soil erosion occurs, farmers abandon cultivation. This can be verified by the decline in NDVI value (Figure 7). Clearly, if the problems of land degradation and landscape fragmentation are not given enough attention, they will hinder the sustainable development of the tourism industry in Sanya.

DISCUSSION

High-resolution remote sensing and detailed socioeconomic data have been used in this study. Based on the combination of remote sensing and GIS spatial analysis, the outcome indicates that there is a trend of farmland conversion to construction land and forestland to orchard. The degree of land-use changes weakens from coastline to island interior. The changes of farmland to construction land mainly occurred in the plain areas along the coastline, while forestland to orchard mainly occurring in middle platform areas. The booming tourism not only contributed to the increased demand of tourism infrastructure and rapid urban expansion in a short period of time, but also boosted the demand of tropical fruit products. Rapid increase of tourism infrastructures occupied large fertile
farmland, urban expansion caused construction land increase and farmland loss, and forest was converted to orchard driven by the high speed of market demand for fruit products. Tourism development dramatically restructured the land-use pattern, which brought about landscape fragmentation, vegetation degeneration, and coastal erosion. Irrational tourism and land development have destroyed Sanya's tourism resources and to some extent dissipated its initial advantage as a tourist destination, which will hinder future sustainable development of tourism. Figure 9 shows the tourism development, land-use changes, and their environmental effects for Sanya City.

At present, there are three important plans related to tourism and land use in Sanya: Sanya general plan for land use (2006–2020), Sanya master plan for tourism development, and Sanya overall urban plan (2008–2020). Each delineates respective maximum benefits that are in conflict with those of other plans and with the protection and exploitation of resources. The project of building Hainan International Tourist Island has been upgraded to the state strategy. As the most important tourist destination, the land use of Sanya is confronted with both real opportunities and challenges. For the long run, an integrated land-use plan is needed to guarantee tourism-led sustainable land use. The following factors should be taken into consideration: (1) the protection of land resource and landscape as the highest prioritized issue, and establishment of a Land Resources Protection Fund; (2) creation of a detailed function zoning of land use, in which natural resources optimization must be payed more attention in order to reverse landscape fragmentation; (3) definition of the boundary of area for developing tourism, which must be clearly defined to restrict the widespread sprawling of accommodation establishments in a low density in order to improve land-use efficiency; and (4) the implementation of a system of land-use planning for required further improvements.

ACKNOWLEDGMENTS

This research was in part supported by National Natural Science Foundation of China (No. 41130748 and No. 41001109) and National Basic Research Program of China (2012CB95570002). It is also facilitated by the Hainan's Department of Lands and Resources.
LITERATURE CITED


