Study on the characteristics of land use structure of key ecological public welfare forest areas in Fujian Province

Xuncheng Fan and Lili Zhao*

College of Urban and Rural Construction, Shaoyang University, Shaoyang, 422000, China

*Corresponding author’s e-mail: 3810@hnsyu.net

Abstract. Based on five-phase remote sensing image data, RS and GIS technologies were used to quantitatively analyze the quantity, rate and structure of land use changes in Shunchang county, Fujian Province, using the relevant calculation model of land use. The results showed that the land use types were frequently converted to each other between 1995 and 2015 in Shunchang county, among which forestland and cultivated land became the land with the most increase and decrease in area, respectively. In terms of the rate of change, the single dynamic degree of forestland, water area and unused land are all positive, among which, water area has the fastest rate of change with a dynamic degree of 9.57%. Grassland, cultivated land and construction land all have negative values, and cultivated land has the fastest rate of decrease. In terms of land use structure, both land development index and reclamation index show different degrees of decreasing trend. This study can provide scientific reference for the rational planning and utilization of land in Shunchang county and the surrounding counties.

1. Introduction

In recent years, due to the rapid economic development, the world population has been growing and the contradiction between population and resources has been highlighted. The concept of sustainable development has emerged in order to alleviate the contradiction and conflict between economic development and resources and environment. Since land resources are limited resources essential for human survival and development, land use/cover change has become an important research area in sustainable development research [1]. In recent years, scholars in China have conducted many studies on land use at different scales, and the results are abundant. For example, Zhao et al. [2] analyzed the land use changes characteristics of the coastal zone region in east Fujian from 2000 to 2014. Lu et al. [3] used a multi-factor integrated evaluation method and applied a coupled coordination model to explore the coordination relationship between land intensive use and land use structure in Qingyang city, Gansu province. Yao et al. [4] used relevant research methods to simulate and analyze the changes of land use structure under the land use control scenario of Beijing from 2015 to 2030. The above studies not only provide scientific references for the rational use of land resources, but also lay the foundation for county-scale land use research. With the continuous economic development, the urbanization rate of small-scale regions represented by counties is obviously accelerated, and the study of land use in counties is of great significance to the long-term stable development of local areas.

Therefore, we take Shunchang county, a key forest area in China and a key ecological public welfare forest area in Fujian Province, as the research area. We study the land use structure of Shunchang county in the past 20 years based on land use classification data. It can quantitatively grasp land use structure evolution law and provide reference for the rational land use of the city in the future.
At the same time, it can also provide reference for the surrounding counties.

2. Overview of the study area
Shunchang county is located in the northwest of Fujian Province, with a county area of 1985 km², is a key ecological public welfare forest area in Fujian Province, the only fir hometown in the country, the national timber strategic reserve base county, with a forest coverage rate of 79.9%. It has a subtropical maritime monsoon climate with an average annual temperature of 18.5°C. With abundant rainfall and flooding in the rainy season, the annual precipitation is 1756 mm, with a total water volume of 33.43×10⁸ m³, which belongs to the abundant water area. At the end of 2019, the gross domestic product was 133.18 billion yuan, the total household population was 23.25×10⁴, and the urbanization rate was 51.3%.

Figure 1. Map of the study area.

3. Data sources and research methods
3.1. Data source and processing
The basic research data used Landsat-5 TM of 1995, 2000, 2005, 2010 and Landsat-7 ETM of 2015 with strip processing in Shunchang county. The spatial resolution of all five phases of remote sensing image data was 30 m. With reference to China's land use classification system and combined with the geographical characteristics of Shunchang county and fieldwork information, the land use types of Shunchang county were classified into forestland, grassland, water area, construction land, cultivated land and unused land. The images were subsequently processed using ENVI and ARCGIS software to obtain the area of each land use type and other related data.

3.2. Research Methodology
3.2.1. Research methods for the rate of land use changes. The change speed of area for a certain land use type can be expressed by a single land use dynamic degree model in a certain period of time. When the calculation result is positive, it indicates an increase in area, and when the calculation result is negative, it indicates a decrease in area [5]. Its calculation formula is as follows.

\[ K_1 = \frac{U_h - U_a}{U_a} \times \frac{1}{T} \times 100\% \]  

(1)

Where \( K_1 \), \( U_a \) and \( U_h \) denote the dynamic degree of a certain land use type, the area of the land use type at the beginning and the end, respectively. \( T \) is the length of study time in years.
3.2.2. Research methodology of land use structure. The land use structure can be expressed by the proportion of one or several land use types to the total area of the study area [6]. According to the research needs, the land development index and land reclamation index are selected in this paper to indicate the structural characteristics of land use. The specific calculation formula is as follows.

The mathematical expression of the land use development index is as follows.

\[ B = \frac{b_i}{A} \times 100 \]  

(2)

Where \( B \), \( b_i \) and \( A \) represent the development index, the area of construction land and the total area of the study area, respectively.

The mathematical expression of the land use settlement index is as follows.

\[ K_2 = \frac{a_i}{A} \times 100 \]  

(3)

Where \( K_2 \) and \( a_i \) represent the land reclamation index and the area of cultivated land, respectively.

4. Results and Analysis

4.1. Quantitative analysis of land use

During the study period, the land use types were continuously reallocated with the continuous economic development. As can be seen from Figure 2, the area of forestland, water area and unused land increased over the 20-year period, with the largest increase in forestland area of 300.3 km². The increase in forestland area is inextricably linked to national policy, as the county was originally a national strategic timber reserve base county. The area of cultivated land, construction land and grassland decreased, and the order of decrease was: cultivated land (-240.4 km²) > grassland (-67.25 km²) > construction land (-17.92 km²). Shunchang county is a national strategic timber reserve county, however, because of frequent meteorological disasters, some of the unsuitable cultivated land and grassland have also been converted to forestland or other land use types, so the area of cultivated land and grassland decreased more during the study period. At the same time, there is also a small increase in unused land because of the low degree of land use intensification.

![Figure 2](image-url)

Figure 2. Changes in area of each land use type from 1995 to 2015.

4.2. Analysis of the rate of land use changes

Generally speaking, the dynamic degree of forestland, water area and unused land is positive, while the dynamic degree of construction land, cultivated land and grassland is negative between 1995 and 2015 (Table 1). It indicates that the change in area of land use types in Shunchang county during this period is "three increases and three decreases", which coincides with the change in land use quantity. Among the land use types that increased in area, the dynamic change of water area was the most...
dramatic, with a dynamic degree of 9.57%. Among the land use types with decreasing area, the most drastic change is in cultivated land, with a dynamic degree of -3.14%. From 1995 to 2000, unused land changed the most actively, with a dynamic degree of 40.23%. From 2000 to 2005, only forestland, water area and unused land increased, with positive dynamic degrees, while the dynamic degrees of the other three land use types were negative, with the most active change in construction land. From 2010 to 2015, the change of water area was exceptionally active, with 51.89% dynamic degree. Thus, it is found that although the overall trend of "three increases and three decreases" is shown during the study period, the dynamic changes of different land use types in different time periods are very obvious.

| land use type     | Study Period       | 1995 to 2000 | 2000 to 2005 | 2005 to 2010 | 2010 to 2015 | 1995 to 2015 |
|-------------------|--------------------|--------------|--------------|--------------|--------------|--------------|
| Construction land |                    | 22.77        | -10.06       | -9.87        | -0.34        | -2.35        |
| Forestland        |                    | -3.31        | 1.72         | 1.43         | 3.16         | 0.62         |
| Water area        |                    | -15.64       | 15.7         | -3.44        | 51.89        | 9.57         |
| Cultivated land   |                    | -6.02        | -2           | 20.59        | -14.18       | -3.14        |
| Unused land       |                    | 40.23        | 19.62        | -14.21       | -18.28       | 0.81         |
| Grassland         |                    | 16.76        | -0.07        | -6.77        | -8.99        | -1.66        |

4.3. Land use structure analysis

The land use development index and reclamation index of Shunchang county are calculated according to Equation (2) and Equation (3) in Figure 3. In general, the land use development intensity of Shunchang county has shown a fluctuating downward trend in the past 20 years. Among them, the development intensity was the lowest in 2005, with a development index value of 1.64. In 1995, the most new construction land was added and the development intensity was the largest, and the development index reached the maximum value of 2.86 in 20 years. As far as land reclamation index is concerned, the degree of land reclamation has changed more. From 1995 to 2000, the land reclamation index of Shunchang county decreased significantly, from 14.3 to 5.28, indicating that the cultivated land area decreased rapidly during the five years. From 2000 to 2010, the land reclamation index continued to increase. From 2010 to 2015, the land use settlement index decreased sharply to its lowest value of 2.07 during the study period. This indicates that the cultivated land area in Shunchang County continued to decrease during these five years, which is related to the conversion of some cultivated land with poor stand conditions to forestland.
5. Conclusions
Based on five periods of land use data, quantitative analysis was conducted on the quantity, rate and structure of land use changes in Shunchang county, Fujian Province, and the results of the study showed that

(1) During the period from 1995 to 2015, the land use types in Shunchang county were frequently converted to each other, with the area of forestland increasing the most, followed by water area and unused land. While cultivated land became the land use type with the largest decrease in area during the study period.

(2) In terms of the rate of change of each land use type, the dynamic change of water area is the most active, with a dynamic degree of 9.57%. The area of grassland, cultivated land and construction land showed a decreasing trend, among which, the dynamic change of cultivated land was the most drastic, with a dynamic degree of -3.14.

(3) In terms of land use structure, the intensity of land use development has not been significant in Shunchang county over the past 20 years. In contrast, the reclamation index showed a fluctuating decrease, and it reached the lowest value during the study period in 2015, at 2.07.

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