Landscape Characteristics and Landscape Resource Utilization of the Lianhe Terraces Agricultural Heritage Site (Postprint)

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Abstract

The Lianhe Terraced Fields in Youxi, Fujian constitute an agricultural heritage system with a history spanning over 1,300 years; however, with the continuous development of industrialization, the stability mechanism of its social-economic-natural complex ecosystem is no longer adapted to the requirements of productivity development, and the landscape ecosystem is facing threats of unsustainability. This study employs landscape ecological principles and methods to analyze landscape metrics and spatial landscape patterns of the Lianhe Terraced Fields, investigate the current status of landscape resources, and propose protection countermeasures for the development and utilization of landscape resources. The results indicate: 1) Forest land and cultivated land are the dominant landscape types in the Lianhe Terraced Fields, accounting for 67.93% and 20.40% of the total landscape area, respectively. The landscape fragmentation (0.05) and number of patches (83) of forest land are relatively low, reflecting high forest coverage and relatively concentrated distribution. The number of patches (1,369), patch density (1,327 patches km 2), edge density (89.91 m hm 2), landscape fragmentation (0.75), and landscape shape index (50.85) of cultivated land are all the highest, reflecting characteristics of cultivated land fragmentation, shape diversification, and complex boundaries. 2) The Lianhe Terraced Fields form a vertical three-dimensional distribution pattern of 'water-source forest-settlement-terraced fields-composite landscape', possessing beneficial productive functions, livability functions, soil and water conservation functions, and aesthetic functions. 3) The Lianhe Terraced Fields harbor abundant landscape resources; however, problems such as extensive landscape resource destruction and failure to deeply explore and utilize these resources persist, causing the Lianhe Terraced Fields cultural heritage site to fall into a vicious cycle of 'landscape resource idleness-heritage site poverty-population loss-terraced field ecological landscape destruction-landscape resource disappearance'. 4) Future

efforts should focus on restoring and transforming terraced field landscapes, establishing corresponding compensation mechanisms, developing ecological agriculture and secondary industries, developing agricultural heritage tourism and ecotourism, and promoting the revitalization of terraced field landscapes and the modern revival of traditional culture.

Full Text

Landscape Characteristics and Utilization in Agro-Cultural Heritage Systems in Lianhe Terrace

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Abstract: Lianhe Terrace in Youxi County, Fujian Province is an important Agricultural Heritage System (AHS) with a history spanning over 1,300 years. The ancestors established a distinctive "forest-settlement-terrace-composite landscape" pattern. This subtropical mountain area has developed abundant landscape resources, including physiographic, biological, astronomical and climate, relic, architectural and engineering, and folk-culture landscapes. However, the stability mechanism of the social-economic-natural compound ecosystem has failed to adapt to productivity development demands driven by industrialization, and the landscape ecosystems face sustainability threats. This study analyzed landscape characteristics using landscape ecology theory and methods, examined the status of landscape resource utilization, and developed conservation strategies for Lianhe Terrace Agricultural Heritage. Results showed: (1) Forest land and farmland were the dominant landscape types, accounting for 67.93% and 20.40% of the total landscape area, respectively. Forest landscape fragmentation and patch number were relatively low (0.05 and 83, respectively), indicating high forest cover with relatively concentrated distribution. Farmland showed the highest number of patches (1,369), patch density (13.27 per 10,000 hm^2), edge density (89.91 $m \cdot hm^{-2}$), landscape fragmentation (0.75), and landscape shape index (50.85), reflecting fragmentation, diversification, and complex boundary conditions. (2) The vertical distribution of landscape patterns in key protected areas exhibited a "forest-settlement-terrace-composite landscape" pattern that established virtuous ecological systems with typical regional traits, functioning optimally for yield, livability, soil and water conservation, and aesthetics. (3) Lianhe Ter-

race Agricultural Heritage possesses abundant natural and cultural landscape resources. However, some terraced fields have been abandoned due to youth out-migration for employment, leading to terrace collapse, canal blockage, and soil erosion. Additionally, some landscapes have been destroyed by natural or human factors, such as historic sites of ancient pottery (over 3,000 years old) and Shuiwei Bridge (Southern Song Dynasty). Furthermore, some cultural landscape resources like Min Opera, the Fuhu Rock Temple Fair, and Lantern Festival lack adequate utilization, creating a vicious cycle of idle resources, poverty, population loss, landscape ecological degradation, and resource disappearance. (4) This unstable vicious cycle mechanism can be reversed through rational landscape resource exploitation. Proposed strategies include restoring damaged forestland, establishing appropriate compensation mechanisms, and developing eco-agriculture, secondary industries, agro-cultural heritage tourism, and ecological tourism. These aim to establish a sustainable terraced artificial ecosystem integrating terraced ecological landscape protection with landscape resource utilization, benefiting both landscape rehabilitation and agricultural cultural heritage preservation.

Keywords: Agricultural heritage; Lianhe terrace; Landscape pattern; Landscape resource; Landscape ecology; Landscape reservation

1 Introduction

Agricultural Heritage Systems (AHS) represent unique land-use systems and landscapes rich in biodiversity, embodying the harmonious co-evolution of humans and nature [1–3]. These systems maintain multifunctional characteristics while supporting local livelihoods [4]. However, rapid industrialization and urbanization have threatened their sustainability, with traditional terraced landscapes experiencing abandonment and degradation [5,6]. As a critical component of AHS, landscape resources encompass natural ecosystems, cultural heritage, and their interactions, requiring integrated conservation approaches [7–10].

Lianhe Terrace, located in Youxi County, Fujian Province (117°48 30 -118°40 E, 25°50 36 -26°26 30 N), covers 3,425.3 km^2 with over 90% mountainous terrain. The core terrace area spans 169.5 km^2, supporting approximately 21,000 residents across 158 villages. The region features a subtropical monsoon climate with annual temperatures of 15.8–19.6°C, 280 frost-free days, and annual precipitation of 1,600 mm (average 1,313.4 mm) [16,17]. The area contains 369 streams and 20 reservoirs, with forest water storage capacity of 4.39$×10^{8}$ m^3, soil conservation capacity of 4.04$×10^{7}$ tons, and water conservation of 8.15$×10^{4}$ tons, alongside 5.99$×10^{4}$ tons of soil retention [16]. This study employs landscape ecology methods to analyze Lianhe Terrace's landscape patterns, resource utilization status, and conservation strategies.

2 Materials and Methods

Landscape pattern analysis utilized Fragstats 3.3 software to calculate metrics at patch, class, and landscape levels [18]. Key metrics included: Total Class Area (CA), Percentage of Landscape (PLAND), Number of Patches (NP), Patch Density (PD), Edge Density (ED), Landscape Shape Index (LSI), and Landscape Fragmentation Index. ArcGIS 9.3 processed spatial data for metric calculation [10,12]. Landscape resource investigation combined field surveys with participatory rural appraisal, classifying resources into physiographic, biological, astronomical/climate, relic, architectural/engineering, and folk-culture categories [13,14].

3 Results

3.1 Landscape Pattern Characteristics Forest land and farmland dominated the landscape composition, representing 67.93% and 20.40% of total area respectively (Table 1). Forest patches showed low fragmentation (0.05) with only 83 patches, indicating concentrated distribution and stable ecological function. In contrast, farmland exhibited the highest patch number (1,369), patch density (13.27 patches $\cdot$ km^{-2}), edge density (89.91 m $\cdot$ hm^{-2}), fragmentation index (0.75), and shape index (50.85), demonstrating significant fragmentation, diversification, and complex boundaries. Construction areas comprised 0.86% of the landscape with high shape complexity, reflecting dispersed settlement patterns.

** Landscape pattern metrics of patch types of the key protected areas of Lianhe terrace**

3.2 Vertical Distribution of Landscape Pattern The vertical distribution distinctly showed the "forest-settlement-terrace-composite landscape" pattern (Fig. 2). Forests occupied mountain tops and upper slopes, settlements were situated mid-slope, terraces extended across middle-lower slopes, and water systems connected the entire landscape. This pattern created integrated ecological functions for production, living, and conservation.

[Figure 2: see original paper] Vertical distribution of landscape pattern in the key protected areas of Lianhe terrace

3.3 Landscape Resources Lianhe Terrace possesses diverse landscape resources (Table 2). Physiographic resources include Jinji Mountain and unique rock formations. Biological resources feature Phyllostachys pubescens forests, Ginkgo biloba, and Taxus chinensis. Astronomical/climate resources comprise observation sites for atmospheric phenomena and summer resorts. Relic resources include 3,000-year-old pottery sites and Southern Song Dynasty bridges. Architectural resources encompass Fuhu Rock temples and traditional dwellings. Agricultural ecosystem landscapes feature the iconic "forest-village-terrace-water" system. Folk-culture resources include Min Opera, traditional

festivals, and agricultural implements.

** Summarizing the distribution and current situation of landscape resource in Lianhe terrace**

However, many resources face threats: ancient sites lack protection, traditional buildings have been demolished or modified, water systems were replaced by modern infrastructure, and cultural practices face generational discontinuity.

4 Discussion

4.1 Composite Ecosystem Functions The "forest-settlement-terrace-water" pattern represents a self-sustaining ecosystem [19]. Forests provide water conservation and soil stability, settlements facilitate resource management, terraces enable agricultural production, and water systems ensure irrigation. This multifunctional landscape delivers ecosystem services including water regulation, soil retention, biodiversity maintenance, and cultural preservation [15]. The system' s 1,300-year persistence demonstrates successful adaptation to mountainous environments.

4.2 Landscape Resource Utilization Issues Out-migration of young laborers has caused terrace abandonment, leading to structural collapse, canal silting, and erosion. Historical sites like ancient pottery ruins and Shuiwei Bridge suffer from natural weathering and insufficient protection. Cultural resources including Min Opera, temple fairs, and traditional techniques face utilization gaps, creating a vicious cycle: resource idleness → economic decline → population loss → ecological degradation → resource disappearance [20].

4.3 Conservation Strategies Sustainable development requires integrated strategies:

1. **Ecological Restoration:** Implement forest conservation and compensation mechanisms [29], restore abandoned terraces, and maintain traditional water systems [21,22].
2. **Industrial Development:** Promote eco-agriculture, secondary processing of agricultural products, and cultural tourism [23,24]. Develop agro-cultural heritage tourism integrating landscape aesthetics with cultural experiences [25,26].
3. **Community Engagement:** Enhance local participation through benefit-sharing mechanisms, cultural education programs, and capacity building to address generational cultural loss [27,28].
4. **Policy Integration:** Establish coordination mechanisms linking ecological compensation, tourism development, and heritage protection to create a sustainable "protection-utilization" cycle.

These strategies aim to transform the vicious cycle into a virtuous one, achieving harmonious development between human well-being and landscape conservation.

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Note: Figure translations are in progress. See original paper for figures.