Chapter 7
Ecosystem Services and Biodiversity of Traditional Agricultural Landscapes: A Case Study of the Hani Terraces in Southwest China

Yuanmei Jiao, Luohui Liang, Toshiya Okuro, and Kazuhiko Takeuchi

Abstract The traditional agricultural landscape has many ecosystem services as well as a rich biodiversity. This paper analyzes the multiple ecosystem services provided by the Hani Terrace landscape in southwestern China. The results indicate: the Hani Terrace landscape is a traditional sustainable rice agriculture landscape which has multiple ecosystem services and a rich biodiversity that are generated from the close relationships between the landscape elements/ecosystems that are maintained by local farmers. However, although the Hani Terrace landscape has almost maintained its original status, it is facing continuous pressures from social and economic development so adequate adaptive management strategies should be developed to meet the challenges.

Keywords Biodiversity • Ecosystem services • Hani Terrace landscape

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7.1 Introduction

Traditional agricultural landscape is the indigenous form of ecologically-based agriculture and relies on the co-evolution of local cultural and environmental systems. It exhibits a high ecological rationale, which is expressed through the intensive use of local knowledge and natural resources, including the management of agro-biodiversity in the form of diversified agricultural systems (Altieri 2004). Compared to modern industrial agriculture, traditional agricultural landscapes are more beneficial to natural ecosystems, but marketable crop yields and production are lower (Millennium Ecosystem Assessment 2005). According to previous study and field survey, we summarize the differences between traditional and modern industrial agricultural landscape by the components, ecological processes, ecosystem services and biodiversity (Table 7.1).

Because of the multiple ecosystem services and rich biodiversity, traditional agricultural landscapes have attracted more conservation concern in the past decade (Swift et al. 2004). Rice is the most important irrigated crop in the world. There are many kinds of traditional rice paddy landscapes in Asia due to the long history of rice cultivation. For example, the Cordillera rice terraces in the Philippines, the Satoyama landscape in Japan, and etc.

In this article, we take one traditional rice paddy/terraces landscape in eastern Asia, the Hani Terraces in southwest China, as a case study, analyze the desirable and non-target ecosystem services within and outside the landscape, and identify the mechanisms that maintain the ecosystem services and biodiversity in the Hani Terraces. We then consider their potential to improve the conservation and revitalization of similar landscapes.

7.2 Brief Description of the Hani Terraces Landscape

The Hani Terrace is a unique traditional agricultural landscape that is suited to the high-relief mountainous region with a subtropical monsoon climate. Due to its outstanding value in world, it was listed in the world cultural landscape heritages in June 2013. It is mainly located in the four counties of Honghe Hani and Yi Autonomous Prefecture, namely: Yuanyang, Honghe, Lvchun and Jinping, which are located in the southeastern part of Yunnan Province, southwestern China (Fig. 7.1). The landscapes are mainly composed of forests (including primary and secondary forests), villages and rice terraces which are flooded with water over the whole year. Its' simplified vertical structure is characterized as up-slope forests, middle-slope villages and down-slope rice terraces (Jiao et al. 2012). The ratio of the main land use systems is as follows: forests/terraces/crop land/other land uses = 3:1:2:1 at the Yuanyang county. People of various races, with Hani being the main ethnic group, have created this spectacular agricultural landscape over 1300 years.

Table 7.1 Landscape components, ecological processes, ecosystem services and the biodiversity status of traditional and industrial agriculture

Parameters	Traditional agricultural landscape	Modern industrial mono-agriculture
Landscape components	Mosaic of large-sized agro-forest land, middle-sized arable land and pasture, small-sized settlements and wet areas	Separated and large-sized arable land, together with pasture and timberland
Ecological processes within the landscape	Mass flows come from natural ecosystems (mainly agro-forest), such as water and renewable nutrients, which are continually moving into the arable land and settlements. Renewable energy from agro-forest and arable ecosystems also moves into the settlements. The whole landscape is under cyclic and dynamic conditions	Water flows and chemical fertilizers are used frequently during the crop growing season. Pesticides are used to kill pests (animals or micro-organisms feed on the crops). Non-renewable energy is used on the arable land and crop products are continually moving to market
Provisioning services	Food (including products from cultivated plants, livestock and the collection of wild flora and fauna), construction timber, firewood, fiber, fresh water and genetic resources	Crop products, timber and fiber
Supporting services	Soil formation, nutrient cycling and primary production	Primary production
Regulating services	Climate regulation, disease regulation, flood control and detoxification	Emissions contributing to climate warming, disease dispersal, flooding and drought, water eutrophication and toxification
Cultural services	Spiritual, recreational, esthetic, inspirational, educational, communal and symbolic values	Communal and symbolic values
Negative effects	Habitat degradation, insufficient product marketing and lower crop yields and production	Habitat loss, competition for pollination, water, pest damage and pesticide poisoning of non-target species
Biodiversity	Rich	Low

The Hani Terraces is a traditional subsistence farming system which provides a number of ecosystem services (Takeuchi 2010; Jiao et al. 2012) including provisioning services, i.e. species that provide us with food, timber, medicines, and other useful products; regulating services, such as flood control and climate stabilization; supporting services, such as soil formation and water purification, and cultural services, which are esthetic or recreational assets that provide both intangible and tangible benefits, such as ecotourism attractions (Kremen and Ostfeld 2005). In addition, it serves as a valuable model of a society in harmony with nature. It has a long history of adaptive management of the semi-natural environment which has led to a rich diversity of plants and animals. Thirdly, it is facing serious challenges at the local and global scale. For example, the Hani Terraces are under considerable

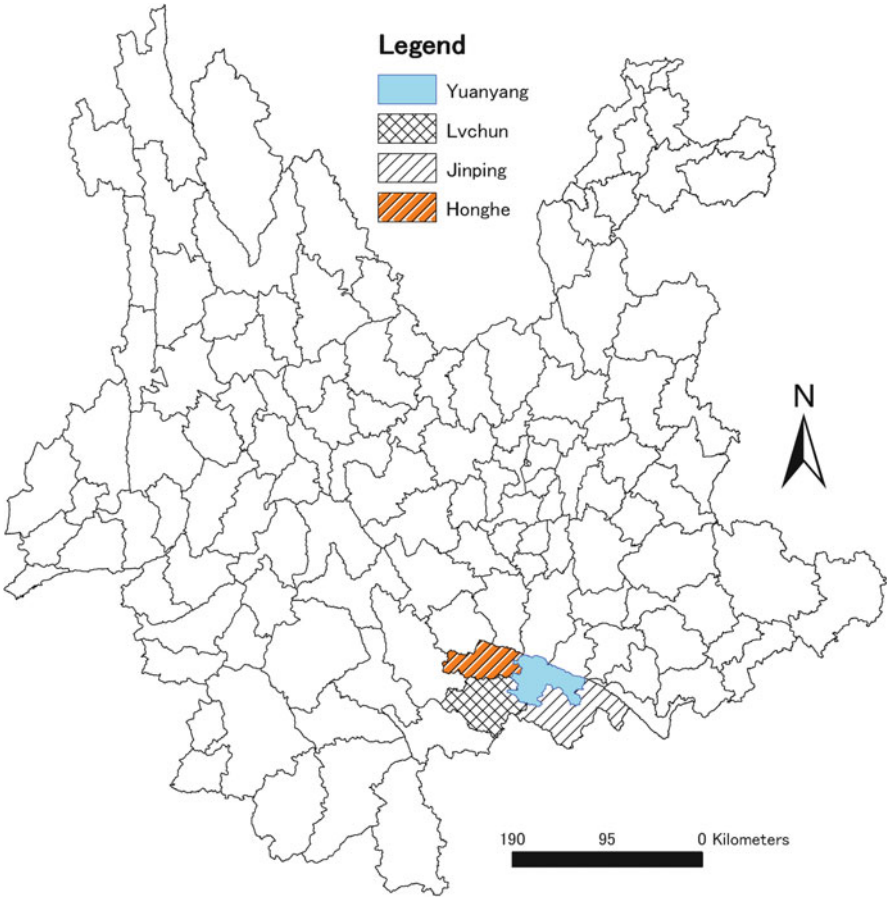

Fig. 7.1 Location of the Hani Terraces in Yunnan Province, south west China

pressure from economic development because of the poverty of local farmers and the under-developed socio-economic conditions.

7.3 Ecosystem Services Provided by the Hani Terrace Landscape

The Hani Terraces are a mosaic of well connected ecosystems including forests, terraces, cropland, grassland and wet areas. Each ecosystem in the landscape has its components, which have multiple ecosystem services that are directly or indirectly related to each other. Due to the spatial separation between on-site and off-site ecosystem services caused by the transfer of biological resources/flows

Table 7.2 Ecosystem services provided by the Hani Terrace landscape

Elements	Forest	Crop land	Wet areas	Settlements	Grassland
Components	Natural forest, natural sacred forest, natural timber-charcoal forest, semi-natural Caoguo forest and cultivated tea plantations	Small sized rice fields full of water, levees made using soil, river valley, channel systems and path systems	Numerous terraced ponds along the river valley, river and a small reservoir	House and livestock corrals, recreational places, roads, drinking water pool, waste water pool, horticultural land, bamboo, fruit trees or sparse trees	Natural grassland or newly planted Grain to Green land
Desirable ES within the landscape	P: fresh water for irrigation and drinking, firewood for heating and light, timber, poles for houses and fences, litter fall, bamboo shoots, wild animals, fruits and mushrooms and medicinal plants; C: cultural inheritance	P: rice, straw, fish and other aquatic animals for meat and semi-aquatic and aquatic plants for food; C: cultural inheritance	P: fresh water; R: flood and drought regulation	P: meat, vegetables, fruits, organic fertilizer; R: manage and maintain the whole landscape; S: cultivated soil formation; C: cultural center for residents and recreation	P: land for grazing, straw for houses and fertilizer
Desirable ES for crop marketing and production	P: Caoguo and tea	P: rice, fish; R: nutrient retention	P: many kinds of aquatic animals and plants	P: meat and vegetables	
Non-target ES outside the landscape	P: fresh water and semi-natural habitats; S: nutrient cycling, and carbon sequestration; R: climate and flood control; C: recreation	P: fresh water, wetland for organisms; R: climate and flood control; C: recreation	P: fresh water and numerous wetlands for organisms; R: climate control	R: multiple use of natural resources; C: ethnic culture, recreation and tourism	P: habitats for species; S: nutrient cycling

[a]*ES* ecosystem services, *P* provisioning services, *R* regulating services, *S* supporting services, *C* cultural services

(Guo et al. 2000), we must first classify the ecosystem services into those "within landscapes" and those "outside landscapes". Secondly, provisioning services, including food, fiber, timber and other subsistence materials for life are the target ecosystem services for farmers, while others, especially regulating and supporting services, are the non-target ones that mainly provide benefits to the public. For this reason, we classify the ecosystem services into "target" and "non-target". Using this dual classification system, we can summarize the ecosystem services provided by each ecosystem in the Hani traditional agricultural landscapes (Table 7.2).

The characteristics of the ecosystem services provided by Hani Terraces landscape are as follows. (1) The components of each ecosystem is very diverse, for example, the forest ecosystem composed of primary forests, secondary forests and shrub forest. (2) The Hani's daily life is mainly dependent on the target provisioning services provided by the terraces and forests, such as rice, fish and other aquatic animals from the terraces, edible hygrophytes from terrace levees and semi-aquatic patches, firewood, timber, edible wild mushrooms, plants, insects and animals from forests. (3) Due to the water shortage for rice planting in high mountains subject to a subtropical monsoon climate, the Hani people have developed very efficient irrigation systems and water conservation strategies in order to regulate water flows. During the regulation process, the Hani have created target ecosystem services for water conservation and have also provided significant non-target regulatory and supporting services for the macro-climate, the hydrological cycle, soil formation and nutrient cycling. (4) The Hani's worldview is one of natural religion, and they believe that many natural things, such as mountains, forests, rivers, terraced fields and rice, have a divine owner that must be respected. Therefore, the Hani have associated the landscape with many types of cultural services. In addition, after the spectacular landscape was publicized by Yann Layma, a French photographer during 1988–1993, the Hani Terraces landscape has become a world famous national and international tourist destination and provides a valuable recreation service.

7.4 Biodiversity Status of the Hani Terrace Landscape

The Hani Terraces are rich in biodiversity compared to China as well as the world (Table 7.3). The table shows the biodiversity in Yuanyang county is very rich in plant and animal species, due to the different vertical zonation of vegetation in the southern and northern parts and the complex terrain and macro-climate conditions (Fig. 7.2). Within the 2,200 km^2 area, the climate moves from a tropical to a temperate climate and the vegetation ranges from high humid monsoon rainforests to dry-hot valley vegetation that is similar to Savanna land. At the same time, centuries of exploitation and utilization by local people has led to diverse, species rich semi-natural habitats that are dependent on human disturbance. According to the YYFB (2011) statistics, the number of plant species used by the local people for timber, dyeing, edible foods, forage, fiber, spiceberry, medicine and oil are

Table 7.3 Species richness of Hani terraces in Yuanyang County of southwestern China. If land area is the denominator and species number is the numerator, then the number of species per 1,000 km^2 can be shown in following way (except the number for the World)

	World	China	Yunnan, China	Yuanyang, China
Area (1,000 km^2)		9,600	390	2.2
Data source	EAJ (2010)	Yang et al. (2004)	Yang et al. (2004)	YYFB (2011)
Mammals	5,490 (21)	0.064	0.779	37.727
Birds	9,998 (12)	0.130	2.077	73.636
Reptiles	9,084 (5)	0.039	0.436	19.545
Amphibians	6,433 (30)	0.030	0.308	17.273
Fish	31,300 (5)	0.402	1.108	49.545
Vascular plants	294,842 (3)	3.424	42.564	660.909

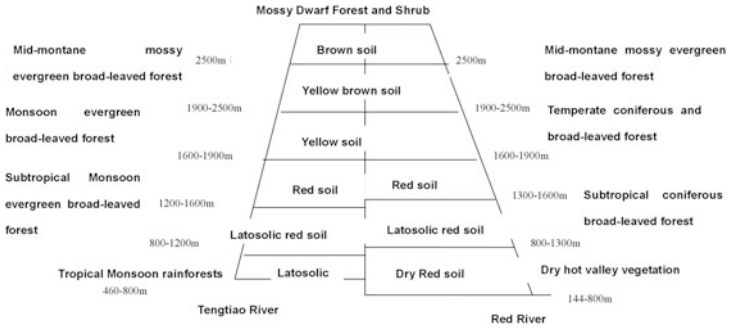

Fig. 7.2 The vertical zonation of vegetation in the southern and northern parts of Yuanyang County, south west China

33, 8, 52, 7, 14, 10, 98, and 23, respectively. In addition, the records of the Agricultural and Technology Office of the Yuanyang Agriculture Bureau showed that in 2008 there were 47 local rice landraces, although many others have been lost because of the expanded use of hybrid rice varieties after the 1980s (Jiao et al. 2012). Therefore, we can say that biodiversity plays an important role in providing provision ecosystem services that improve the wellbeing of the Hani and, at the same time, the semi-natural habitats created by the land management practices carried out by local people benefit biodiversity.

7.5 Discussion

The Hani Terraces landscape has changed very little over time, but the development of economy and society are putting continuous pressures on ecosystem services and biodiversity. For example, the wonderful beauty of the terraces attracts many national and international tourists, which has meant that tourism has become an

important industry in Yuanyang County. Nevertheless, the conflicts between farmers and tourist companies are very serious because the beautiful scenery is created and maintained by farmers, but their considerable recreational value only benefits the tourist companies and local government. Secondly, large numbers of tourists consume lots of wild edible plants, as well as the upstream water. This has led to the local extinction of some wild species and water shortages for irrigation in downstream areas. Therefore, the balances between different ecosystem services, biodiversity and human wellbeing should be paid more attentions to solve them.

In conclusion, although the Hani terrace landscape has many target and non-target ecosystem services as well as a rich biodiversity, it will change with the pressures come from the inside and outside world. In order to keep the multifunction of the landscape, the multiple services it provides and the biodiversity it reserve, a sustainable management system should be adopted to conserve the whole landscape (Takeuchi et al. 2003).

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