

Chapter 14

Comparative Studies on Pattern and Ecosystem Services of the Traditional Rice Agricultural Landscapes in East Asia



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

Abstract The traditional agricultural landscape is a multifunctional geographic object, which can provide multiple ecosystem services for human beings due to complex interactions between components, patterns, processes, and dynamics. Taking the Satoyama landscape in Japan and the Hani terrace landscape in southwestern China as objects, this paper reviews and compares their patterns and multiple ecosystem services. The results indicate that both landscapes are composed of similar elements, including forests, villages, wet rice paddies or terraces, grasslands, streams, ponds, and irrigation ditches. However, they differ in distributing area, spatial pattern, ecosystem services, and socio-ecological pressures. The main elements of the traditional Satoyama landscape are secondary forests and small, gently sloping, rice paddies. Its spatial pattern is a heterogeneous mosaic of seminatural ecosystems, and the prevailing ecological process is the flow of organic fertilizer. As the landscape has been abandoned because of various social pressures (the aging farming population, urbanization, and economic globalization), its current ecological service is mainly cultural—providing Japan with a symbol of traditional rural lifestyle. The Hani terraces are still a vigorous, living landscape, which provides all kinds of ecological services for local people and tourists. This life in the landscape stems from its reciprocal effects, feedbacks among the vertically ordered components of natural and seminatural forests, villages, and huge, steeply sloping rice terraces. Because they are traditional agricultural landscapes,

Y. Jiao (✉) · X. Gao
School of Tourism and Geography Science, Yunnan Normal University,
Kunming 650500, P.R. China
e-mail: ymjiao@sina.com

T. Okuro · K. Takeuchi
Graduate School of Agricultural and Life Sciences,
The University of Tokyo, Tokyo 113-8657, Japan

L. Liang
Institute for Sustainability and Peace, The United Nations University,
Tokyo 150-8925, Japan

both the Hani terraces and the Satoyama are facing continuous pressures from social and economic development. Learning the efficient, adaptive management strategies from Satoyama can help Hani rice terraces meet the challenges.

14.1 Introduction

Agricultural lands comprise about 40% of global terrestrial area (FAO 2009). Although its primary services are the provision of food, fiber, and fuel, agriculture—as an ecosystem directly managed by human beings—plays a unique role in both supplying and relying on ecosystem services (Swinton et al. 2007; MA 2005; Zhang et al. 2007). The links within the agricultural landscape, namely the landscape pattern and process, impact the ecosystem services provided to society (Matson et al. 1997). Thus, it is essential to assess agriculture's ecosystem services from a landscape perspective (Tschardt et al. 2005).

Rice is the most important irrigated crop in the world (FAO 2009). Due to the long history of rice cultivation in Asia, there are various kinds of traditional rice paddy landscapes that provide multiple ecosystem services to local people. Taking as study objects two traditional rice paddy/terrace landscapes in eastern Asia, the Satoyama in Japan and the Hani terrace landscape in southwest China, this article summarizes and analyzes the two areas' characteristics and ecosystem services. The study's aims are: (1) to compare the landscapes' pattern and ecosystem services, (2) to analyze the target and nontarget ecosystem services within and outside the landscapes, (3) to discuss the landscapes' current status and the challenges they are facing, and (4) to find lessons learned from Satoyama that may benefit the sustainability of the Hani rice terraces.

14.2 Components and Features of the Satoyama and the Hani Terrace Landscape

The traditional Satoyama landscape is a mosaic of secondary forests (also called Satoyama forests), wet rice paddies, cultivated fields, grasslands, streams, ponds, and irrigation ditches surrounding a Japanese farming village—the entire landscape necessary to supplying the needs of a community (Fukamachi et al. 2001; Kobori and Primac 2003; Takeuchi et al. 2003). Because the Satoyama landscape is the traditional rural/agriculture landscape of Japan, its features exist on a national scale (Table 14.1), and the two most famous Satoyama landscapes are the rice paddies located in Noto Peninsula and Sado Island (Fig. 14.1).

The Hani terrace landscapes are composed of forests, ponds, villages, rice terraces inundated all year, and dry fields. They are located in the Honghe Hani and Yi Autonomous Prefecture, in the southeast part of Yunnan Province, southwestern

Table 14.1 Components and features of the Satoyama and the Hani terrace landscape

Indicator	Satoyama landscape	Hani terrace landscape
Location	23°–45°N, 125°–142°E	22.5°–23.5°N, 100°–103°E
Spatial scale	National/Japan	County/Yuanyang, Lvchun, Jinping, Honghe
Area (ha)	6,000,000–9,000,000 ^a	1,112,300
Terrain	From low-relief mountains to hills, lowlands, and valley bottoms	From high-relief mountain peak to deep carved river valley, distributed across the whole mountainsides
Climate	Temperate monsoon	Subtropical monsoon and vertical climate
Total annual precipitation (mm)	1000–2000	700–2400
Average temperature (°C)	10	17
Elevation range (m-a.s.l.)	175–195	105–2940
History	Yayoi era (300 B.C. ~ A.D. 300)	Tang dynasty (A.D. 618 ~ 903)
Landscape composition	Satoyama woodlands, other crop fields, grasslands, wet rice paddies, villages, streams, reservoirs, artificial ponds, irrigation ditches	Natural and secondary forests, year-round inundated rice terraces, dry fields, grasslands, villages, streams, numerous artificial small terraced ponds, and irrigation ditches
Area proportion of landscape composition	Forests: paddies: other crop fields = 1:1:1 at village scale ^b	Forests: terraces: dry lands: other land uses = 3:1:2:1 at county scale (Yuanyang)
Current status	Abandoned and underused since 1960s	Mostly are kept in original status

^aCited from Takeuchi et al. (2003, p. 46)

^bCited from Washitani (2001)

China (Fig. 14.1). People of various races, with the Hani people being the main ethnic group, have maintained this spectacular agricultural landscape for over 1300 years (Table 14.1). Compared to the Satoyama landscape, the Hani terrace landscapes are concentrated in this specific bio-cultural region. They are a unique traditional agricultural land use system in the high-relief mountainous region with a subtropical monsoon climate.

Both the Satoyama and Hani landscapes are traditional subsistence farming systems, which provide a bundle of ecosystem services (Takeuchi 2010; Jiao et al. 2012), including provisioning services (species used as food sources, timber, medicines, and other useful products); regulating services (flood control, climate stabilization); supporting services (soil formation, water purification); and cultural services (aesthetic or recreational assets, such as ecotourism attractions, providing tangible and intangible benefits) (Kremen and Ostfeld 2005). In addition,



Fig. 14.1 Location of the Satoyama in Japan and the Hani terrace landscape in SW China

both landscapes are facing serious challenges on local and global scales, although these challenges differ in natural and social respects. For example, owing to economic globalization and the aging of local farmers, the Satoyama landscape was underused or abandoned, which caused a decrease in bio-cultural diversity. On the contrary, the Hani terrace landscape is under high pressure to develop economically because of the poverty of local farmers and underdeveloped socioeconomic conditions. In this circumstance, it may be argued that the Hani terrace landscape is in the early overuse stage that the Satoyama landscape faced before the 1960s.

14.3 Spatial Pattern and Ecological Process in the Satoyama and the Hani Terrace Landscape

Landscape pattern—the spatial arrangement of ecosystems—can influence the horizontal and vertical flows of materials, such as water, sediments, or nutrients (Peterjohn and Correll 1984), and other important ecological processes, such as net primary production (Turner 1989). Therefore, landscape pattern can affect the spatial distribution and delivery of ecosystem services. The center of the Satoyama landscape is the settlement surrounded by small, gently sloping rice paddies, and large areas of secondary forests (Fig. 14.2a). All the ecosystems or elements in the

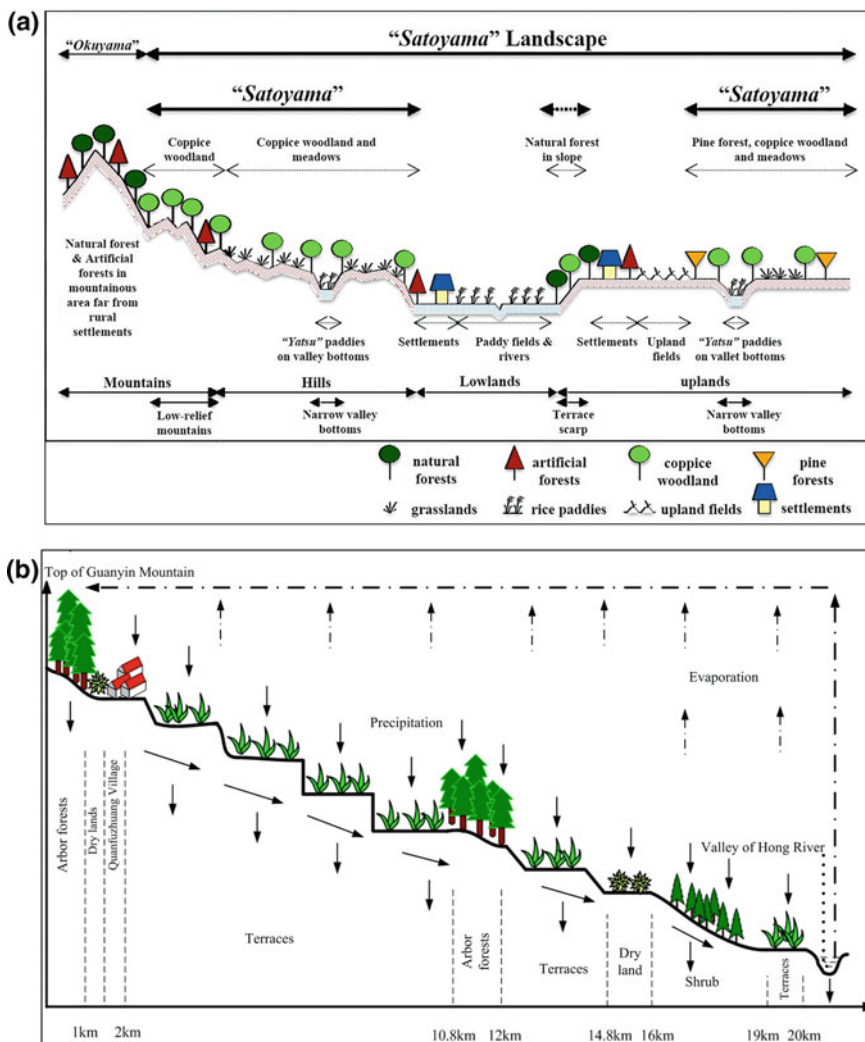


Fig. 14.2 Spatial structure from high mountains to river valley with strongly connected elements in **a** the Satoyama landscape (after Yamamoto 2001, from Takeuchi et al. 2003) and **b** the Hani terrace landscape

Satoyama landscape were once strongly connected to each other through the agricultural land use system (Takeuchi et al. 2003), mainly via organic fertilizers, such as manure, fodder, ash, and forest litter.

The Hani terrace landscape stretches across the whole mountain slope, with the natural forests on the mountaintops as one major landscape element (Fig. 14.2b). The forest-village-terraces structure along the Hani landscape's slope forms an efficient resource circulation system. The water from the forests runs through an

irrigation network to reach the hamlets first, followed by the terraces. Then it continues downslope into the river valley (Jiao et al. 2012). This flow of water and nutrients in the Hani landscape is important to the provision of ecosystem services, since those services are controlled by, and normally characterized by, complex ecological processes and functions that sustain and improve human life (Daily 1997).

14.4 Ecosystem Services of the Satoyama and the Hani Terrace Landscape

Both the Satoyama and the Hani terrace landscape are mosaics of well-connected ecosystems, including forests, human settlements, rice paddies/terraces, and water areas. Each landscape element has substantial components, which have multiple ecosystem services that are directly or indirectly related to each other. These ecosystem services are divided into “within” and “outside” categories, due to the transfer of biological resources/flows, which spatially separates on-site and off-site ecosystem services (Guo et al. 2000). The ecosystem services are also classified into “target or desirable” and “nontarget” categories because, for example, provisioning services, including food, fiber, timber, and other subsistence materials, are the target ecosystem services farmers pursue, while others, especially regulating and supporting services, are the nontarget categories, which mainly benefit the public. The ecosystem services provided by the two traditional agricultural landscapes are summarized in Table 14.2.

According to Fukamachi et al. (2001), Washitani (2001), and Takeuchi et al. (2003), each element in the traditional Satoyama has its special functions or target ecosystem services related to the traditional daily life of Japanese people. For example, coppice forests were traditionally used to produce fuelwood and charcoal; to feed cattle and horses; to collect chestnuts, young shoots of ferns, herbs, and mushrooms as foods; and to gather litter in winter and green manure in summer to fertilize rice paddies or crop fields. The grasslands provided fodder for livestock, straw for homes, and organic fertilizer for rice planting. All the other landscape components provided special products or goods for local peoples, directly or indirectly (Table 14.2). Due to the continuous utilization and management of coppicing, mowing, irrigating, and harvesting over centuries, the Satoyama landscape became a heterogeneous mosaic of habitats, which consisted of a succession series of forests, grasslands, water areas, and rice paddies. In addition, collecting organic fertilizer from forests and grasslands to fertilize rice paddies consolidated the relationship between landscape elements, thus generating a conglomerate of regulating and supporting services (Table 14.2). The landscape has also generated many kinds of cultural services, such as nonmaterial spiritual and religious benefits, recreation, aesthetic values, and the cultural heritage of historic sites, including sacred woodlands, shrines, temples (Fukamachi et al. 2011).

Table 14.2 Ecosystem services of the traditional Satoyama landscape and the Hani terrace landscape

Landscape elements	Satoyama landscape				Hani Terrace landscape			
	Components	Desirable ES within landscape	Desirable ES for marketing	Nontarget ES outside landscape	Components	Desirable ES within landscape	Desirable ES for marketing	Nontarget ES without landscape
Forest	Coppice, fuelwood, secondary forest, fir forest, pine forest	P: litterfall, green leaf manure, firewood for heating and light, timbers, poles for house and fence construction, bamboo shoots, wild fruits and mushroom for food; medical plant C: recreation	P: timbers	P: seminatural habitats for species S: nutrient cycling, carbon sequestration, phyto-remediation R: climate and flood regulation C: recreation	Natural forest, natural sacred forest, natural timber-charcoal forest, seminatural Caoguo forest, cultivated tea plantation	P: freshwater for irrigation and drinking, firewood for heating and light, timbers, poles for house and fence, litterfall, bamboo shoots, wild animals, fruits and mushroom; medical plant C: culture inheritance	P: Caoguo (large cardamom) and tea	P: freshwater, seminatural habitats for species S: nutrient cycling, carbon sequestration R: climate and flood C: recreation
Cropland	(1) Paddy field (2) rain-fed (3) dry land	P: rice, straw, wheat	P: rice	P: small water area or wetland for organisms R: climate and flood, alleviation of nonpoint source pollution	Small sized rice field full of water, levee made by soil, river valley, channel system, pathway system	P: rice, straw, fishes and other aquatic animals for meat, semiaquatic and aquatic plants for food C: culture inheritance	P: rice, fishes R: nutrient retention	P: freshwater, wetland for organisms R: climate and flood C: recreation
Water area	River, reservoir	P: freshwater, fishes	P: freshwater, wetland for organisms	P: freshwater, wetland for organisms	Numerous terraced ponds along river	P: freshwater R: flood and drought regulation	P: freshwater, numerous	P: freshwater, numerous

(continued)

Table 14.2 (continued)

Landscape elements	Satoyama landscape				Hani Terrace landscape			
	Components	Desirable ES within landscape	Desirable ES for marketing	Nontarget ES outside landscape	Components	Desirable ES within landscape	Desirable ES for marketing	Nontarget ES without landscape
	and soil bank	R: flood and drought regulation		R: climate	valley, river, small reservoir			wetland for organisms R: climate
Village or settlement	House and livestock corral, shrine, road, vegetable land, bamboo, chestnut tree, dung yard, seedbed	P: meat, vegetable, chestnut, organic fertilizer R: manage and maintain the whole landscape S: cultured soil formation C: cultural center of residents	P: meat and vegetable	R: multiple utilities of natural resources C: recreation and tourism	House and livestock corral, amusement place, road, drinking water pool, wastewater pool, vegetable land, bamboo or fruit tree or sparse tree	P: meat, vegetables, fruits, organic fertilizer R: manage and maintain the whole landscape S: cultured soil formation C: cultural center of residents, recreation	P: meat and vegetable	R: multiple utilities of natural resources C: ethnic culture, recreation, and tourism
Grassland	Burning and mowing grassland	P: fodder for livestock, straw for house, fertilizer		P: habitats for species S: nutrient cycling, C: recreation	Natural grassland or newly planted grain to green land	P: land for grazing, straw for house, fertilizer		P: habitats for species S: nutrient cycling

P: provisioning services; R: regulating services; S: supporting services; C: cultural services (modified from Jiao et al. 2014)

Compared to the Satoyama landscape, the Hani terrace landscape is different in the following aspects.

1. It encompasses not only secondary forests, but also natural forests, tea gardens, and huge, steeply sloping rice terraces inundated all year.
2. The current Hani's daily life is mainly dependent on terrace and forest target provisioning services—such as the rice, fish, and other aquatic animals from terraces, edible hygrophytes from terrace levees and semiaquatic patches, firewood, timber, edible wild mushrooms, plants, insects, and animals from forests.
3. Due to the limited water supply for planting rice in high mountains with a subtropical monsoon climate, the Hani people have developed an excellent irrigation system and water conservation strategies to regulate water flow. During the regulating process, the Hani people have realized the target ecosystem services of water conservation and also the significant nontarget regulating and supporting services for macro-climate, hydrological cycle, soil formation, and nutrient cycling.
4. The Hani people believe many natural things, such as mountains, forests, rivers, terraces, and rice, all have a divine owner who must be respected. Therefore, the Hani terrace landscape provides many types of cultural services. Additionally, the Hani terraces have produced a highly valued creation service for both national and international societies, after the spectacular landscape was publicized by Yann Layma, a French photographer, from 1988 to 1993. His work made the Hani terrace landscape a world-famous tourist destination.

14.5 Challenges in the Satoyama and the Hani Terrace Landscape

According to the *Statistical Handbook of Japan 2011*, because of the highly developed economy and the aging of farmers, Japan's cultivated acreage shrank year after year from 6.09 million ha in 1961 to 4.59 million ha in 2010. The most common cause for the decrease was cultivation abandonment, accounting for approximately 44.0% of all cases. As one of the consequences of land abandonment, in fiscal year 2009, the self-sufficiency rate of all foods, except rice and vegetables, was highly dependent on imports from foreign countries (Statistics Bureau 2011). A similar phenomenon also happened in lumber production. Therefore, abandoning the Satoyama landscape and importing ecosystem services led to the biodiversity and ecosystem services crises in Japan, due to the loss of human-dominated seminatural habitats. In addition, high risks of climate change correlate to decreased ecosystem services in many ways (Table 14.3).

As for the Hani terrace landscape, although now it is still keeping its original status, economic and social development strategies are putting continuous pressures on its ecosystem services (Table 14.4). For example, the wonderful beauty of

Table 14.3 Biodiversity and ecosystem services crises in the Satoyama (summarized from report of *the third national biodiversity strategy of Japan—JG 2007*)

Crises	Drivers	Indirect pressure	Ecosystem services	Responses
First crisis Overuse: species and habitat degradation	Excessive human activities: industrialized monoculture, coniferous plantations, urbanization	Social demands due to rapid economic growth	People want to get efficient production of large amount of ecosystem services	Habitat restoration strategic environmental assessment
Second crisis Underuse (Satoyama issue: degradation of Satochi-Satoyama)	Insufficient level of management: abandonment of secondary forests, low-profitable rice terraces and other croplands	Social aging problem and shortage of rural labor after rapid economic growth period	Dependence upon imported foreign ecosystem services including foods, timber, and energy	Sustainable use of local resources; management of abandoned plantations; large-scale wildlife management
Third crisis Ecosystem disturbances	Artificially introduced alien species, chemical contaminations	Homogeneity of vast, intensively managed areas Decreasing of natural enemies for alien species	Degradation of regulating and supporting services	Monitoring and management of invasive species population; concentrated management scheme for prioritized targets
Climate change crisis Huge potential for species extinction and ecosystem collapse	Loss of estuary and seashore habitats, high risks of extreme climate	Population explosion, global scale degradation of natural vegetation	Degradation of regulating and supporting services	Enhancement of monitoring; developing adaptation methods

terraces attracts numerous national and international tourists. Thus, tourism has become a pillar industry in Yuanyang. Nevertheless, the conflicts are very serious between farmers and tourism companies because the beautiful scenery is created and maintained by farmers, but the marketed recreation value only benefits the company and local government. Additionally, large numbers of tourists consume lots of wild, edible plants, as well as upstream water, thus exhausting some wild species and causing water shortages for irrigation in downstream areas. Therefore, the trade-offs among different ecosystem services and human well-being have become difficult risks.

At present, the Hani terrace landscape is facing many challenges, such as severe droughts caused by global climate change, landslides and terrace collapse caused by

Table 14.4 Challenges faced by the Hani terrace landscape

Items	Challenges
Loss of rice landraces	In 1980, there were 195 local and 47 wild rice landraces, respectively; in 2008, only 48 local rice landraces were recorded. Tropical and subtropical areas were planted with hybrid rice varieties (Jiao et al. 2011)
Drought	March to May 2005, a “37-year return drought” occurred, and about 1200 ha of terraces suffered from the drought (Zuo 2005). April 2010, the Hani terrace landscape suffered another 100-year drought, and about 3300 ha of terraces were damaged (Ren 2010)
Changes of forests	Due to the implication of policies and economic development strategies, such as grain to green and the poverty elimination project, many croplands, and tea gardens are converted to plant <i>Alnus nepalensis</i> , <i>Anomum tsao-ko</i> <i>Crevest et Lemaire</i> and <i>Radix Isatidis</i> are planted under the forest canopy. Rubber trees are planted in the southern part. <i>Eupatorium adenophorum</i> <i>Spreng</i> has invaded in bare land, grassland, and the forest fringe area
Change of rice terraces	The rice terraces located in the dry-hot valley have been changed into tropic croplands for bananas, etc. Almost all the main ditches are consolidated in Quanfuzhuang River basin (about 10% of the total). Only the three paddy levees owned by one family were consolidated in 2005
Landslides	All were relatively small landslides, averaging 30 m in width, 20 m in length, and 3–5 m in depth
Social pressures	Extreme poverty of local farmers, migrating labor of younger generations, and conflicts among stakeholders including farmers, tourism companies, and local governments

a vulnerable environment of steep slopes and friable metamorphic rocks, loss of rice landraces caused by the expansion of hybrid rice and application of modern agricultural technology, poverty of local peoples, loss of traditional ecological knowledge, off-farm labor migration caused by social and economic factors, and conflicts among stakeholders in tourism development.

Although originally both the Satoyama and the Hani terrace landscape had many target and nontarget ecosystem services, these have changed, and will continue to change, with the pressures from both the inside and the outside worlds. Adaptation of sustainable management is essential to conserving the landscapes and keeping their multiple functions and multi-services (Takeuchi et al. 2003).

14.6 Lessons from the Satoyama Crises to Benefit the Development of the Hani Terrace Landscape

Compared to the three crises of the Satoyama landscape, the Hani terrace landscape is still managed in a traditional, rice-farming way. It provides multiple ecosystem services because most Hani people, including younger generations, still depend on

the terrace landscape to survive, and the holders of traditional knowledge are passing their oral legacy to new generations, although few young residents know all of it.

Currently, many strategies have been proposed and implemented to revitalize the Satoyama landscape, such as the “Satoyama Initiative,” the “Sub-global assessment of Satoyama and Satoumi in Japan,” “The 10th Conference of the Parties (COP 10) to the Convention on Biological Diversity (CBD),” and related strategies. It should be noted that these strategies’ most essential idea is to find dynamic, balanced interactions between human and nature in the long term, and to rebuild a sustainable, low-carbon, resource-circulating, and nature-harmonious society with an eye toward resilience enhancement (Takeuchi 2010). In 2011, two pilot sites of the Satoyama landscape were designated as Globally Important Agricultural Heritage Systems (GIAHS). One of them is “Sado’s Satoyama in harmony with Japanese crested ibis.” At present, valuable actions of environment-friendly farming are being carried out on Sado Island in the Niigata Prefecture. Through winter flooding of rice paddies, together with organic farming and fish ladders, the Satoyama has been restored to provide a suitable habitat for many aquatic species, such as crested ibises, loaches, and other fish. The rice produced there is certified as “Creating villages coexisting with crested ibises,” and it is then traded at higher prices than ordinary rice. In this system, ecosystem services and human well-being are integrated into a multifunctional landscape. The Sado success can be used as a revitalizing model for rural development in Japan.

Some lessons can be learned from the Satoyama evolution to help manage the Hani terrace landscape.

1. The Satoyama was abandoned because of aging farmers as a result of decreasing birth rates and younger generations migrating to cities seeking higher income. Now, the Hani terrace landscape is facing the same problems of losing the younger generation. In the near future, the Hani landscape will be facing terrace abandonment. Therefore, determining how to increase the farmers’ income and human well-being is vital to maintaining the whole landscape. The brand-certified rice produced by this area should be traded at higher prices via specific policies. Efficient management of local resources is the most important strategy to conserve biodiversity as well as ecological services.
2. The consolidation of irrigation and drainage systems, paddy levees, and the banks of both river and pond has diminished habitat quality and caused fragmentation by cutting off the flow of water and nutrients in the Satoyama landscape. Thus, the application of agricultural technologies in the Hani terrace landscape should consider a new kind of building material, rather than concrete, which will preserve flow connectivity and the seminatural habitats for the conservation of biodiversity and ecological services.
3. To combat global climate change, the Hani rice terraces should also enhance monitoring and develop corresponding adaptation methods from both scientific and indigenous ways. New strategies and policies should also be put into practice to protect the rich rice landraces and endangered species.

In 2010, a report on the background of the “Satoyama Initiative” compared cases from many countries, including Kenya, Tanzania, Argentina, Mexico, Sri Lanka, Cambodia, Bangladesh, India, Spain, Australia. In this report, the Satoyama landscape was defined as a “socio-ecological production landscape,” a name which highlights the various physical structures, management techniques, and governance systems that characterize these landscapes, the benefits they provide, or the threats they currently face. In this way, the “Satoyama Initiative” can reorganize the importance of these landscapes for ecosystem services and human well-being, as well as promote reconstructing mechanisms for managing such landscapes internationally (Takeuchi 2010). The Hani terrace landscape should learn from these international cases, such as the Satoyama crises, to avoid the negative effects of modernization and globalization and instead cultivate a sustainable path to development.

Acknowledgements This study was funded by the Environment Research and Technology Development Fund (E-0902) of Japan’s Ministry of the Environment, and by the National Natural Science Foundation of China (grant numbers 40401022, 41271203, 41761115). The authors also thank for Anton Pijl and the other anonymous reviewer for their constructive comments, and the editors for their editing of the manuscript.

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