

Research paper

Developmental Context and Local Practices of Satoyama

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ABSTRACT

The term “Satoyama” is a traditional Japanese word. In 2010, during the 10th Conference of the Parties to the Convention on Biological Diversity (CBD COP10), the Ministry of the Environment of Japan and the United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS) jointly proposed the “Satoyama Initiative” and its international partnership network. This initiative, which received significant attention from experts and scholars at the conference, was recognized as a potential tool for promoting biodiversity conservation. Shortly afterward, Taiwan also introduced the concept of Satoyama. Through the collaboration of government agencies, academia, and civil society organizations, efforts were made to revitalize rural communities, and the principles of the Satoyama Initiative gradually took root in Taiwanese communities, leading to many successful implementations. This literature review qualitatively examines recent developments in Satoyama. In total, 32 recent and significant international publications on Satoyama are analyzed and categorized in terms of four major themes: Definition and components, management, applications, and challenges. The primary objective is to clarify the developmental trajectory of Satoyama, identify key findings from recent studies, and explore future trends. The review aims to provide a reference for future Satoyama research and practical implementation in Taiwan, while providing insights for future policy formulation.

Keywords: Satoyama, Landscape, Biodiversity, Ecosystem service

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INTRODUCTION

In 2010, the Aichi Biodiversity Targets were formally adopted. By 2020, however, some countries had failed to fully achieve the commitments under the Aichi Targets, and the number of commitments had declined markedly across successive stages of the process, from planning and reporting to implementation. Among these, Targets 8 (Pollution), 4 (Production and Consumption), and 18 (Traditional Knowledge) exhibited the lowest levels of effective implementation. Further, owing to marked disparities among countries, some were unable to fulfill their initial commitments, as they received insufficient financial support or had underdeveloped scientific and technological capacity. The limited effectiveness of biodiversity conservation is likely to exacerbate the global biodiversity crisis (Maney et al. 2024). In this context, the unique semi-natural conditions of Satoyama landscapes play a crucial role by enabling local residents to sustainably use the abundant natural resources while also conserving biodiversity, thereby raising broader public awareness of its importance. According to the National Biodiversity Strategy and Action Plan (NBSAP) of Japan, Satoyama has been implemented in 40% of the country's territory. Given the high biodiversity that this approach supports and the dependence of numerous species on anthropogenic habitat mosaics, NBSAP designates the conservation of Satoyama areas as a national priority for Japan (Dunbar and Yanagiya, 2024). Other studies have noted that Satoyama has been implemented in approximately 67% of Japan's land area, mostly distributed across hilly, densely forested regions, linking urban areas with remote mountainous zones and integrating diverse environmental types,

forming a complex mosaic (Fukamachi, 2017).

Japan's nationwide Satoyama assessment initiative can be traced back to 2007. The Japanese government collaborated with the United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS) to launch the Japan Satoyama Satoumi Assessment (JSSA) (Dunbar and Yanagiya, 2024). This assessment, grounded in the theoretical framework of the United Nations Millennium Ecosystem Assessment published in 2005, recognized that long-standing and close interactions between humans and ecosystems have shaped and sustained Satoyama and Satoumi (Fukamachi, 2020). The JSSA analyzed changes in Satoyama and Satoumi ecosystems over the preceding 50 years, along with the diverse driving forces behind these changes, including technology, climate change, socio-behavioral responses, and governmental and economic policies. The assessment also established possible future scenarios for 2050 (Fukamachi, 2020). The findings of the JSSA revealed that Satoyama landscapes are not merely predefined models of pristine nature but are rather ecosystems shaped by varying degrees of anthropogenic disturbance. In practice, these landscapes can support higher biodiversity than many low-density land-use types, while simultaneously delivering human well-being in resilient communities. However, over the last decade, rapid industrialization, urbanization, and other threats have eroded traditional landscape management practices, imperiling biodiversity (Dunbar and Yanagiya, 2024). The results of the assessment were ultimately released in 2010, followed by the 2012 publication of *Satoyama-Satoumi Ecosystems and Human Well-being: Socio-ecological Production Landscapes of Japan*. This publication provided comprehensive information on the

status and trends of Satoyama and Satoumi landscapes across Japan, establishing a robust scientific foundation for the *Satoyama Initiative* (Fukamachi, 2020).

In October 2010, at the Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD COP 10) held in Nagoya, Aichi Prefecture, Japan, the Japanese Ministry of the Environment and the UNU-IAS jointly proposed the Satoyama Initiative, commonly referred to as the *Satoyama Initiative*. Formally adopted in Decision X/32, this initiative was recognized as an effective instrument for implementing the Aichi Targets and received considerable attention from scholars (Fukamachi, 2017).

Taiwan introduced the Satoyama Initiative approach at the end of 2010, coinciding with the Rural Regeneration Plan, which was actively promoted at the time. The following year, National Dong Hwa University (NDHU) took the lead in applying to join the Initiative, becoming the first official member from Taiwan to join the International Partnership for the Satoyama Initiative. In 2016, the Forestry Bureau of the Council of Agriculture (now restructured as the Forestry and Nature Conservation Agency of the Ministry of Agriculture) established the Taiwan Partnership for the Satoyama Initiative with the assistance of NDHU. This network connects partners dedicated to Satoyama across Taiwan, facilitates the sharing of practical experience, and strengthens professional capacity.

This review of the recent international literature examines Satoyama in terms of four major themes: Definition and components, management, applications, and challenges. The primary objectives are to clarify the developmental trajectory of Satoyama, identify key insights from the contemporary

literature, and examine potential future developmental trends. The review aims to provide a reference for Satoyama-related research and practical implementation in Taiwan and to offer insights that may inform future policy development.

MATERIALS AND METHODS

To elucidate the recent developmental trajectory of Satoyama, this qualitative review analyzed multiple internationally published works on Satoyama. The steps for literature retrieval and screening are described as follows:

- (1) Using “Satoyama” as the keyword, we conducted a literature search between November 4 and November 30, 2024, across multiple international academic electronic databases, including ScienceDirect On-line, MDPI, Taylor & Francis Online, Springer Nature Link, and the International Association for the Study of the Commons.
- (2) The sources were initially ranked by their relevance to Satoyama using the built-in sorting function of each database, supplemented by manual eligibility screening to determine the final inclusion. In addition to journal articles, relevant thematic chapters from academic monographs were incorporated.
- (3) Publications were further screened by publication year, with the primary selection focusing on studies published between 2020 and 2024. For instance, the unexpected outbreak of the COVID-19 pandemic in January 2020 and its impacts on Satoyama warrant in-depth exploration. Nevertheless, a number of seminal works published prior to this five-year window were retained for analysis, specifically studies by Kohsaka et al. (2013), Iwata

et al. (2014), Fukamachi (2017), Kamada (2018), and Saito et al. (2018). These studies were retained owing to their high citation frequency and foundational importance in Satoyama research.

- (4) Although the Satoyama concept originated in Japan, analogous practices and philosophies have also emerged in regions outside Japan. We therefore included various studies conducted outside Japan that focused on Satoyama-like landscapes, to provide an overview of its development in other regions.

Ultimately, 32 English-language publications were selected, constituting the core literature database for this study. Since the concept of Satoyama originated in Japan, incorporating Japanese-language literature would be ideal for capturing the most current developments. However, owing to the authors' language constraints, the publications collected from the international academic databases were primarily in English. This represents a limitation of this study.

From the 32 publications included, the information on Satoyama was extracted and

categorized, via an iterative process of reading and comparison, into four thematic categories—definition and components, management, applications, and challenges—to facilitate subsequent collation and analysis. The research workflow is illustrated in Figure 1.

RESULTS AND DISCUSSION

Definition and composition of Satoyama

The term *Satoyama* (里山) originates from the traditional Japanese word *Satoyama* (さとやま). Etymologically, it is a compound of *sato* (里), representing settlements or villages, and *yama* (山), referring to the surrounding hills and mountains. Geographically, Satoyama refers to the foothill zones between *Okuyama* (奥山) and *Satochi* (里地). Here, *Okuyama* refers to remote, inland mountainous regions that are traditionally regarded as the abodes of local deities, retain their primary forest physiognomy, and are rarely accessed by humans. In contrast, *Satochi* refers to the lowland plains that host human settlements

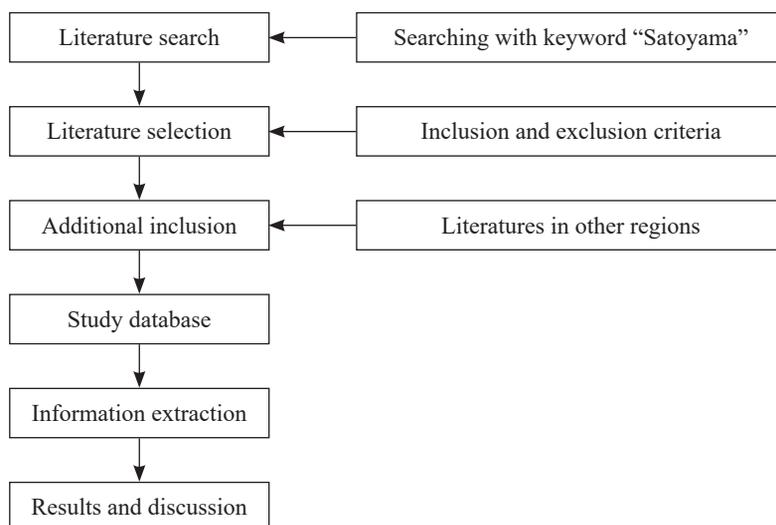


Figure 1. Review process workflow

and agricultural activities (Dunbar and Yanagiya 2024).

In terms of Satoyama residents' perception their environment, the *mura* (village) lies at the core of the landscape, surrounded by *nora* (cultivated fields), which are in turn encircled by *yama* (woodlands), with the *Okuyama* (primitive forest) forming the outermost boundary. This structure forms a multilayered concentric pattern of village–farmland–forest (*mura–nora–yama*), shaping a space in which humans and nature have a symbiotic relationship (Matsumura 2022) (Figure 2).

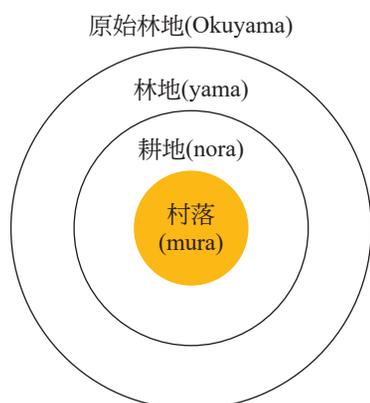


Figure 2. Residents' perception of the Satoyama structure (Adapted from Matsumura, 2022).

In Kamiseya, Miyazu Cit (Kyoto Prefecture, Japan), the terraced paddy fields have undergone large-scale abandonment, resulting in the reforestation of some cultivated plots. Nevertheless, several terraced paddy fields surrounding residential areas have been retained and are still cultivated, thus preventing the disappearance of the traditional Satoyama village–farmland–forest land-use pattern (Fukamachi 2017).

According to JSSA records, the term *Satoyama* originally referred exclusively to “mountains surrounding rural villages, human settlements and houses”. With the evolution of environments across time and space, an

increasing number of studies on Satoyama have produced new findings, gradually expanding the definition of *Satoyama* to encompass a more comprehensive landscape framework. In addition to the original mountainous areas, this expanded definition incorporates human settlements, farmlands, grasslands, inland waters, and other landscape features (Dunbar and Yanagiya 2024). Consequently, a broader definition of *Satoyama* encompasses any “extensive rural environments regularly managed by humans” (Matsumura 2022).

The Satoyama Initiative is dedicated to advancing biodiversity conservation and the sustainable use of natural resources. It achieves this by drawing on exemplary landscape management practices from Japan and other regions of the world and by developing and supporting mutually beneficial relationships between humans and nature (Dunbar and Yanagiya 2024). The case studies by members of the Satoyama Initiative examine regions encompassing the most representative cultural landscapes worldwide. A common feature of the regions examined is the long-term interaction between humans and nature, through which multifunctional landscapes have been shaped over time. While maintaining or enhancing biodiversity, these landscapes also sustain the human well-being of local communities (Torralba et al. 2023). Beyond encouraging participation by national and local governments, the Satoyama Initiative actively welcomes membership applications from communities, indigenous peoples, private companies, academic institutions, and both intergovernmental and non-governmental organizations. After becoming official members, entities are obligated to submit at least one case study demonstrating the application of landscape approaches that balance productive economic

development with the conservation of socio-ecological values, thus sharing their implementation experiences with other members (Torralba et al. 2023).

The Japanese Ministry of the Environment, which has implemented ecological restoration in Satochi–Satoyama areas, defines “Satochi–Satoyama” as “conceptually, an area geographically situated between urban areas and pristine natural regions, whose environment is shaped by the efforts of diverse human activities and characterized by features such as secondary forests surrounding rural villages, as well as farmlands, ponds, and grasslands” (Iwata et al. 2014). In their study on Scenario B for a low-carbon society in Japan, Iwata et al. (2014) point out that Satoyama refers to “secondary forests that have historically supported rural villages by providing firewood, charcoal, and organic fertilizers for each household.” Citing various studies, Sarker (2020) describes Satoyama as referring to “Japanese mountain villages composed of terraced paddy fields, secondary forests, irrigation ponds, and human settlements.” Hirahara (2020) describes it as follows: “Satoyama originated in rural Japan, and this traditional landscape is composed of various ecosystems such as farmlands, secondary forests, and grasslands, sustaining the livelihoods of local residents. People collect organic fertilizer from grasslands for farming and produce firewood and charcoal in the surrounding forests.”

In their questionnaire survey-based study, Nagao et al. (2021) describe Satoyama as “a traditional Japanese agricultural landscape including secondary forests, irrigation channels, rice paddies, pastures, and villages,” providing photographs of actual Satoyama landscapes. Piras et al. (2022) describe it as “a traditional Japanese cultural landscape integrating diverse features of forests, rice

paddies, grasslands, ponds and channels, with close functional interrelationships among distinct elements,” emphasizing that *igune* landscapes and small woodland landscapes included in their study also fall within the scope of Satoyama. Finally, Katsuda et al. (2022) note that “Satoyama is a socio-ecological production landscape composed of secondary forests, farmlands, grasslands, and local communities. Within Satoyama, people have historically relied on natural resources for their livelihoods and inadvertently created favorable habitats for many animals and plants while conducting anthropogenic management activities.” Therefore, although there are various different academic interpretations of Satoyama, these are not mutually contradictory. In summary, Satoyama integrates rural livelihoods, ecological conservation, and social culture, constituting a vibrant and inclusive landscape management model.

As a traditional Japanese rural landscape, the Satoyama Initiative describes Satoyama landscapes as socio-ecological production landscapes and seascapes (SEPLS). This concept refers to the landscapes formed by the interwoven features of different ecosystem types, including secondary forests, plantation forests, farmlands, irrigation ponds, wetlands, grasslands, beaches, coastal areas, and human settlements. In a broader sense, such landscapes incorporate both terrestrial Satoyama and marine coastal Satoyama areas (Saito et al. 2020). Under the long-term land-use practices of local residents, diverse ecosystems, such as paddy fields, dry farmland, forests, and ponds, have become interspersed to form a dynamic patch-mosaic landscape. Areas with diversified land use can provide various resources required for human life and agricultural production, including fallen leaves collected from forest floors (for

field fertilization), wild plants gathered from forests (for food preparation), human excreta from households (used as compost fertilizer), and roofing materials from large grasslands (for roof maintenance). Such use of natural resources does not deplete natural capital, but instead promotes biodiversity, and these environments often contain more species than areas with less diversified land-use (Kamada, 2018).

Hara et al. (2021) analyzed parcel-level land-use changes over more than 40 years in Minabe Town and Tanabe City (Wakayama Prefecture, Japan), finding that in plum orchards, each parcel of land has a specific function that changed over time. Such management practices, in which land parcel function changes over time, are commonly observed in Japanese Satoyama landscapes. Compared with those in many other countries, the agricultural parcels in these plum orchards are extremely small, with the largest in the study sample area being only 0.23 ha (Hara et al. 2021). In other countries, in contrast, agricultural parcels are often much larger, containing multiple land-cover types such as ponds, forests, and grasslands. This difference implies that governmental land-use regulation needs to adopt different approaches. Hara et al. (2021) concluded that conserving the biodiversity within these parceled dynamic mosaic landscapes requires looking beyond single landscape parcels or individual species.

Kohsaka et al. (2013) have summarized the following four characteristics of Satoyama and Satoumi in Japan:

1. Satoyama landscapes exhibit a mosaic structure formed by interwoven terrestrial and aquatic ecosystems, including forests, plantation forests, grasslands, farmlands, pastures, ponds, and channels, with terrestrial ecosystems comprising the majority.
2. Satoumi refers primarily to the mosaic

of marine and terrestrial ecosystems comprising coasts, rocky shores, tidal flats, coral reefs, and seaweed and seagrass beds.

3. The management of Satoyama and Satoumi landscapes requires the integration of traditional knowledge and modern science.
4. Biodiversity is central to the resilience and proper functioning of Satoyama and Satoumi landscapes.

Landscapes exhibiting Satoyama and Satoumi mosaic features are not confined to Japan, but are widely distributed worldwide. Although various functions and structures within these landscapes vary slightly by locality, and their names vary by region, they are conceptually similar (Kohsaka et al. 2013). For instance, In South Korea, traditional village groves, managed by the village's self-organized community, are the common property of the village. These cultural landscapes, known locally as *Maeulsoop* or *Bibosoop*, include well-maintained groves that serve protective functions, often providing flood control and acting as windbreaks. Such groves also have aesthetic value, are used for leisure, recreation, and prayer, and serve as wildlife habitats. During the period of Japanese colonial rule in Korea, however, grove ownership and usage rights were redistributed, reducing the villagers' ability to utilize them, leading to grove degradation (Kweon and Youn 2021).

In West Java Province, Indonesia, an agroforestry system called *Talun-Kebun* (or *Talun-Kebon*) has been developed based on local ecological knowledge. This system involves growing many species of perennial and annual plants in forests that structurally similar to natural forests. This system serves multiple functions for local residents, enabling them to cultivate high-value cash crops and providing temporary job opportunities for

economically disadvantaged residents. The system mitigates hydrological impacts and soil erosion, while providing a natural genetic reservoir owing to its high species diversity. This traditional and sustainable agricultural model is still practiced in parts of the region (Kurniawan and Kurniawan, 2022).

A similar agroecosystem approach is found in Wayanad, Kerala, India, a cool upland region within the Western Ghats. Interestingly, the place name Wayanad derives from the local term *Vayal Nadu* (or *Wayal Nadu*), meaning “land of rice fields”. The local rice agroecosystem comprises three cultivation zones: lowland paddy fields, farmsteads with nearby mixed woody-crop systems, and upland woody crops. Local farmers rely on ecosystem services such as food production, livestock rearing, and groundwater conservation for their livelihoods. In recent years, efforts have been made to promote the cultivation of traditional rice varieties by farming households (Bhatt et al. 2023).

In Spain, Dehesa represents a multifunctional system for livestock grazing and hunting. In areas practicing this system, more than half of the land is converted to pasture, which is interspersed with scattered acorn-producing trees; the acorns from these trees are used to feed a variety of native livestock, including Merino sheep and Iberian pigs. Dehesa involves agricultural practices complementary to grazing, including the cultivation of cereal crops, as well as forestry practices such as the seasonal utilization of oak trees. In addition, this system contributes uniquely to the cultural heritage of Europe, in that cork-oak bark is harvested every 8–10 years to produce cork stoppers for wine bottles (Ruiz-Labrador et al. 2023).

The Chyulu rangeland in Kenya is characterized primarily by arid and semi-

arid landscapes. During the dry season, this land serves as a grazing reserve for wildlife and local agropastoral communities and is home to abundant flora and fauna. The grasslands support livestock, the source of the pastoralists’ livelihoods, and the soil supports carbon sequestration. The Maasai people, who live in this harsh environment, practice the traditional Oloopololi management approach of rotational grazing, maintaining seed banks, and conserving biodiversity. They manage rangeland reserves effectively to support for livestock during the dry season, holding collective land ownership. Nonetheless, the land in Chyulu has become degraded owing to overgrazing, poor collective rangeland governance, and the decline of indigenous traditional knowledge. In response, local communities have recognized these problems and are actively intervening to reverse the trend of ecosystem degradation (Nyongesa et al. 2023).

Although the definition of Satoyama has broadened and its constituent elements have become more diverse, Iwata et al. (2014) point out that most Japanese people still regard densely forested areas as the ideal Japanese rural landscape type, Satoyama. This perception is reflected in the results of the public nomination project *Nihon no Sato 100 sen* (The Top 100 Japanese Rural Landscapes), organized by the Asahi Shimbun. Among the nominated sites, 38% were classified as forest landscapes, with a forest-cover rate as high as 88% within one square kilometer, and forest-type landscapes ranked first on the nomination list.

Shimpo (2022) reviewed multiple academic articles on Satoyama conservation actions, reporting similar findings. In many of these studies, Satoyama is interpreted primarily as woodland: approximately half of them discuss woodland management, while

few examine other components of Satoyama such as grasslands, farmlands, ponds, and streams. Thus, both the public and researchers tend to associate Satoyama primarily with forests or woodland, although this perception does not fully reflect the broader definition of Satoyama.

As an example, the village of Iba (Higashiomi City, Shiga Prefecture, Japan) is located west of Lake Biwa and adjacent to Ibanaiiko Lagoon, and the two waterbodies are connected by the Daido River. The village has low, flat terrain with crisscrossing waterways, and the landscape thus differs, in the public's perception, from the forest-rich Satoyama landscape. Woodland occurs only on Mount Kinugasayama in the southeastern corner, where vegetation such as jolcham oak (*Quercus serrata*), Japanese red pine (*Pinus densiflora*), and bamboo forests grow along the slopes. In contrast, reeds grow densely along the lakeshore, requiring regular burning or cutting, and non-native fish species must be removed from the lake on an ongoing basis (Fukamachi, 2020). This case highlights the importance of continued Satoyama environmental education to gradually reduce such misconceptions.

Management of Satoyama

As emphasized in the core vision of the Satoyama Initiative, "realizing a society in harmony with nature", traditional Satoyama management practices have developed through the long-term use of these landscapes by local residents and the regular management of natural resources. Common practices, including collecting, burning, weeding, logging, soil tilling, and pruning, have historically supported the development of forestry and agriculture in Satoyama landscapes (Kamada, 2018). Through ongoing interactions between humans and

nature, anthropogenic disturbance plays a critical role in such landscapes (Hirahara, 2020). For instance, disturbances caused by regular weeding and branch pruning by residents inadvertently clear habitat space for certain species, forming important habitats and creating biodiversity hotspots. In a study conducted by Katayama et al. (2021) in rice paddy areas of central Japan, the extent of farmland abandonment at the landscape scale was found to determine habitat heterogeneity. Under a moderate abandonment rate, when cultivated land and abandoned farmland are interspersed, habitat heterogeneity increases with the number of abandoned farmlands, and bird occupancy and richness in the rice ecosystem reach their highest levels. However, at high abandonment rates, the landscape is dominated by abandoned farmland, and habitat heterogeneity may decrease, leading to a decline in species diversity. These findings indicate that mosaic landscapes formed by both managed and abandoned rice paddies benefit bird richness, and that appropriate Satoyama management remains necessary.

Iwachido et al. (2020) conducted a survey in Yokohama City and Kamakura City (Kanagawa Prefecture, Japan), comparing the diversity and species composition of plant and butterfly communities in parkland and agricultural land. Although these land-use types differed in native plant species composition, they did not differ significantly in native plant or butterfly species richness or diversity. Iwachido et al. (2020) reported that park management practices that emulate traditional agroforestry practices were implemented to maintain biodiversity; such measures included periodic interventions to prevent tree toppling and control succession from grassland to forestland. In contrast, lower diversity of both plant and butterfly

communities was observed for land abandoned for at least three years, where tall and highly competitive dominant plants species had become dominant. Their findings reveal that nature-oriented park use, retaining the original site landscape, topography, artificial waterscape, and vegetation, is a feasible alternative to maintain the rich biodiversity of the Satoyama ecosystem (Iwachido et al. 2020).

Residents can sustainably benefit from the various ecosystem services provided by Satoyama. Table 1 lists the many ecosystem services provided by Satoyama, in four key categories: providing resources for humans, regulating natural processes, providing cultural benefits, and supporting ecosystem processes. When examining public perceptions and values regarding landscapes, intangible assets, such as cultural ecosystem services, are important but easily overlooked. Katsuda et al. (2022) conducted a questionnaire survey of local residents, tourists, and high school students in Tsukuba City (Ibaraki Prefecture, Japan) to examine public perceptions of wild cherry blossoms and the social values associated with their ecosystem services. The perceived value of the ecosystem services provided by wild cherry blossoms varied considerably among these socio-cultural groups. Unlike local residents and tourists, high school students exhibited little interest in Satoyama's diverse cultural values in terms of aesthetics, recreation, and history, based on their evaluations of aesthetic values, knowledge of cherry blossom varieties, and the spatial distribution of the landscapes that they perceived as valuable. Using the landscape-value method, Kovács et al. (2022) examined visitors' perceived value of cultural ecosystem services in a peri-urban Satoyama forest known as "Kaisho no Mori" in Seto City (Aichi Prefecture). As with Katsuda et

al. (2022), Kovács et al. (2022) found that forest-use patterns were significantly related to socio-demographic attributes. Visitors aged over 60 constituted the majority, with notably few solo female visitors; most of the female visitors were married women and were with their families. Most of the respondents perceived the Satoyama forest as possessing both natural and aesthetic values; based on a photo-evaluation survey, they assigned diverse values, including recreational, spiritual, educational, therapeutic, and cultural-historical, to this Satoyama forest.

Under local resource-sharing traditions, the mosaic structure of Satoyama landscapes is dynamically maintained through regular harvesting of natural resources. The different regional norms in resource-sharing, suited to the local conditions, help to avoid the "tragedy of the commons" (Kamada 2018). In the Fujiwara area of Minakami Town (Gunma Prefecture, Japan), the Uenohara landscape, located approximately 1100 m above sea level, is dominated by grasslands and *Quercus crispula* forests. The local community has established various institutions to manage the common resources and prevent their abuse. First, within the Uenohara landscape, the land with available resources is roughly equally allocated among groups of households known as *Kumi*, which function as labor-sharing units. Second, the leader of each *Kumi* determines when resource use is permitted. Those who violate the rules will be excluded from the benefits of the next season's cooperative labor activities (Hirahara 2020), and residents are strongly opposed to the disruption of community order by outsiders. For individuals, frequently relocation between such groups creates significant inconvenience; this disincentive has historically served as an informal mechanism for maintaining social order (Hirahara 2020).

Table 1. Ecosystem services provided by Satoyama landscapes.

Ecosystem Services	Items	References
Providing resources for humans	Abundant and high-quality water resources for agriculture	Fukamachi 2017
	Non-market food sources	Saito et al. 2018
	Reeds along the lagoon used for making sunshades	Fukamachi 2020
	Stone used as building materials for vegetable garden walls and terraced field embankments	
	“Kaya,” which refers to grasses used for thatching roofs	Hirahara 2020
	“Kacchiki” and “Kapposhi,” which refer to organic fertilizers for farming	
	“Igune” landscape, which provides ingredients for traditional medicine	Piras et al. 2022
Providing cultural benefits	Food-sharing culture	Saito et al. 2018
	Parks provide aesthetic and recreational value for urban residents	Iwachido et al. 2020
	Restorative and healing effects	Nagao 2021
	Food production education	Sehra and MacMillan, 2021
	Maintaining and improving the physical and mental health of the elderly	Shimpo 2022
	Traditional Satoyama landscapes generally hold aesthetic, recreational, and historical value	Katsuda 2022
	Wild cherry blossoms draw people’s attention to the environment	
	Viewing landscapes enhances aesthetic, natural, and spiritual values	Kovács et al. 2022
	Small shrines are considered to have cultural, historical, and religious value	
	Rice fields are attributed with productive, cultural–historical, natural, and educational value	
Regulating natural processes	Regulating water resources through the traditional “yugakari” system	Fukamachi 2017
	Controlling harmful insects in park grasslands	Iwachido et al. 2020
	“Noyaki,” controlled burning to protect grasslands from shrub encroachment	Hirahara 2020
	Maintaining forests around plum orchards to protect watersheds and prevent slope collapse	Hara et al. 2021
	Allowing wild boar hunting to control population size	Sehra and MacMillan 2021
	Letting floodwaters inundate parts of rice fields	Katayama et al. 2021
	“Igune” landscape serve as a windbreak, preserving a stable growth environment for crops	Piras et al. 2022
Supporting ecosystem processes	Parks serve as habitats for native vascular plants and butterflies	Iwachido et al. 2020
	Thickets provide nesting spaces for Japanese honeybees, which pollinate plum trees	Hara et al. 2021
	In plum orchards, the growth of grass contributes to nutrient cycling	

Drawing on contemporary experience with the resource utilization and management of Japanese rice terraces, Sarker (2020) classified rice-terrace commons that have been affected by recent population declines as a quasi-public economic resource. Sarker (2020) argues that the polycentric approach of Elinor Ostrom, which involves local, regional, and national stakeholders, can address the problem of insufficient production in depopulated commons. This approach allows local urban residents to purchase annual-usage rights for these rice terraces. However, despite the economic losses associated with high production costs, urban residents still produce rice in these rice terraces, which continue to provide ecosystem services that protect the landscape (Sarker 2020).

The Satoyama agricultural model has been widely recognized by the United Nations Food and Agriculture Organization (FAO), and many Satoyama landscapes in Japan have been added to the Globally Important Agricultural Heritage Systems (GIAHS) list. GIAHS is an international conservation initiative that actively promotes the national and international recognition of agricultural heritage systems to raise public awareness. Its guiding principles encompass the concept of SEPLS of the Satoyama Initiative (Saito et al. 2020). In 2011, the Satoyama and Satoumi landscapes of the Noto Peninsula, Japan, were added to GIAHS. The Noto Peninsula is characterized by continuous mountain and hill landscapes in which the agricultural land has been well maintained under traditional management practices, with terraced fields nestled between mountains and the sea. The peninsula, which is surrounded by the sea on three sides, boasts abundant marine resources, especially shellfish, and local residents have developed unique foods and a distinctive local culture based on these resources. Along with

Sado Island in Sado City, Niigata Prefecture, these landscapes were the first sites in Japan to be added to GIAHS (Kamiyama 2020). In the Minabe–Tanabe Ume System in Wakayama Prefecture, the landscape primarily exhibits plum orchards, which are surrounded by coppice forests, hedgerows, bamboo, and other vegetation types. Hedgerows are planted in each plot to resist the strong winds, and local residents use the bamboo to make essential items for daily use. The vegetation in the Ume agroecosystem serves provides nectar, and the pollinating Japanese honeybee (*Apis cerana japonica*) inhabits the coppice forests. To improve plum production efficiency, some orchards are now located on flattened areas, recently developed through large-scale land excavation and filling. However, the traditional hillside plum orchards, which exhibit a dynamic landscape mosaic, host more native species and exhibit higher plant diversity (Hara et al. 2021).

The water resource management system of the traditional sustainable rice-paddy agricultural system in Osaki City (Miyagi Prefecture, Japan) has given rise to the traditional practice of “*igune*” landscape cultivation. “*Igune*” plots are cultivated primarily on the northwest side of farmhouses and small cultivated plots, while low shrubs are planted on the south side of farmhouses to protect non-aquatic crops from damage by northern winds, while also allowing direct sunlight to reach the farmhouses and small vegetable gardens. Based on spatial analysis of “*Igune*” landscapes from 2002 to 2021, their number, size, and spatial pattern have hardly changed over this period. The concept of “*Igune*” embodies the identity of intangible cultural heritage, sustaining traditional forest-related knowledge and local identity (Piras et al. 2022). The three Japanese landscape types that have been added to GIAHS highlight the

fact that “the rich and diverse agricultural biodiversity is closely related to wild fauna and flora and contains precious indigenous knowledge and cultural resources.” Notably, indigenous knowledge does not refer exclusively to knowledge from indigenous people, but includes all wisdom derived from long-term interactions between local residents and the environment. Many farmers also “rely on the various goods and services provided by agricultural heritage systems to obtain food and livelihood security” (Fukamachi, 2017).

In contemporary society, Satoyama is no longer solely a rural concern. Urban-rural interactions have become increasingly dynamic, and a growing number of urban residents are willing to participate in Satoyama activities. For instance, willingness-to-pay systems, which reconnect urban residents far from Satoyama landscapes with farmers in these areas, can inject new vitality into Satoyama landscape management. Nagao et al. (2021) found that willingness-to-pay varies with respondents’ perceptions of nature. Respondents who conceptualized nature in terms of Satoyama or natural forest expressed greater willingness, whereas those who conceptualized it as urban nature, suburban nature, or plantation forest expressed lower willingness. The greater willingness of the former group was due mainly to their greater concern for the environment. Those who conceptualized the landscape as Satoyama reported a greater sense of restoration from visiting these environments, while they did not experience this from visiting artificial natural environments. Satoyama landscapes provide the largest restorative effects, which are believed to originate from a sense of security and nostalgia for traditional Japanese agricultural landscapes (Nagao et al. 2021).

Sehra and MacMillan (2021) employed a combination of research methods, including

choice experiments, semi-structured interviews, and field surveys, finding that consumers were willing to pay a higher price for rice produced in Satoyama landscapes (747 JPY more than for rice cultivated in non-Satoyama landscapes). Higher willingness-to-pay generates additional income for farmers, helping to support the management of Japan’s extensive and fertile paddy fields and to maintain agricultural biodiversity and other environmental benefits at the landscape scale. The Satoyama revitalization policies implemented in Kamiseya, Miyazu City (Kyoto Prefecture) in the 1990s provide a further example. The Kyoto Prefecture and Miyazu City provided some financial support, and local private companies that recognized the value of Kamiseya’s Satoyama landscapes provided funding to non-profit organizations, sparking new civic initiatives. Large areas of traditional terraced paddy landscape in the surrounding mountains were restored and preserved through this support. Although the total funding received for Satoyama revitalization was limited, it provided the driving force behind the initiation of Satoyama conservation in the area (Fukamachi, 2017).

Applications of Satoyama

Many of the Japanese Satoyama landscapes discussed here are located in remote rural areas. However, it is also important to consider Satoyama activities conducted in peri-urban areas or urban green spaces. Depending on their proximity and accessibility, urban residents may be able to engage more closely with Satoyama landscapes, thus contributing to conserving these landscapes (Xiang et al. 2022). In the productive urban landscapes of the peri-urban areas of Tokyo, residents can participate in many different activities in the Satoyama

woodlands, including branch thinning and pruning, weeding understory shrubs, cultivating vegetables in abandoned fields, and making handicrafts using mountain and forest resources (Hino et al. 2023). Hino et al. (2023) studied the contributions of these activities to physical activity in 80 participants of similar ages, about half of whom were women. The participants spent more time (up to 4.4 hours) on woodland-related activities than on the other activity types, with woodland-related activities producing higher metabolic equivalent expenditure (Hino et al. 2023). Although elderly visitors to Satoyama woodlands exhibit relatively low metabolic energy equivalent expenditure rates, long-term low-intensity physical activity helps to promote health and well-being among the elderly. The total caloric expenditure of elderly people using Satoyama woodlands contributes about one-third of their national weekly recommended caloric expenditure. Satoyama woodland activities also provide elderly people with regular opportunities for social interaction with other participants (Hino et al. 2023). Further, urban residents with intellectual disabilities can also enjoy the health benefits of participating in Satoyama woodland management activities. From a social empowerment perspective, such activities enable people with disabilities to acquire vocational skills and engage in the production of vegetables and fruits (Shimpo, 2022).

In urbanized landscapes, managing nature-oriented parks to emulate Satoyama systems can help to balance agricultural land-use and the need to respond to the accelerated abandonment of Satoyama landscapes (Iwachido et al. 2020). Such parks contribute to biodiversity conservation, help to maintain aesthetic landscape features, and provide cultural services in terms of their

aesthetic and recreational value. Although the importance of Satoyama landscapes for maintaining biodiversity has consistently been emphasized, Shimpo (2022) found that urban residents were not aware of the direct benefits of participating in Satoyama-based activities. The motivation for engaging in Satoyama conservation extends beyond nature conservation, as it directly promotes health benefits, social cohesion, and recreation, while supporting resource utilization. Emphasizing the recognized short-term benefits of participating in Satoyama conservation will help to motivate more residents to participate (Shimpo, 2022).

The integrated Satoyama landscape conservation system implemented in Niiharu (Yokohama City, Kanagawa Prefecture) is widely recognized as a successful model. The area originally exhibited a large expanse of neglected forests and farmland. In the early 2000s, the Niiharu Citizen Forest Conservation Association and the Niiharu Citizen Forest were established successively. The municipal government supported and facilitated this process and managed communications, successfully integrating public and private land in the region. Today, this citizen participation model brings together multiple stakeholders, including the original landowners, citizens interested in Satoyama conservation, and civic groups. Participant activities are run from the Niiharu Satoyama Exchange Center, which located in a renovated old house. In the next stage, a low-cost, open, and transparent decision-making process will be implemented to further improve Satoyama management (Matsumura, 2022).

During the COVID-19 pandemic, the high transmissibility of the virus prompted governments worldwide, including that of Japan, to impose lockdown measures to

prevent its rapid spread. Members of the public experienced physical and mental exhaustion due to pandemic control measures. Even young people, generally regarded as the healthiest age-group, suffered from pandemic-related stress, developing mental health problems such as anxiety, depression, and fear. In a survey comparing participation in household food production and food-sharing systems before and after the COVID-19 pandemic, Kamiyama et al. (2023) identified voluntary self-isolation as a turning point. The pandemic prompted men, young people, and urban residents, who were previously less engaged, to participate in household food production and food-sharing activities, helping to reestablish the vitality of home gardens. The future development of local agriculture and food systems in Japan depends closely on whether residents can maintain these household consumption habits in the post-pandemic era.

Shortly after the pandemic, Xiang et al. (2022) examined the psychophysiological effects of routine Satoyama activities in small-scale urban green spaces in a mountainous forested part of Matsudo City (Chiba Prefecture, Japan). This revealed that such activities achieved significant benefits for both elderly and young people. In elderly people, both systolic and diastolic blood pressure were significantly lower after Satoyama activities, particularly among individuals with hypertension; further, indicators of negative emotions were reduced, indicating positive health outcomes (Xiang et al. 2022). For younger participants, blood pressure remained within the normal range before and after Satoyama activities, and while their psychological indicators improved, the magnitude of this improvement was smaller for elderly people. These findings suggest that encouraging urban youth to

participate more actively in Satoyama activities may help to improve their mental well-being and alleviate pandemic-related stress (Xiang et al. 2022). The COVID-19 pandemic transformed urban life. To address societal vulnerabilities, ecologically oriented urban activities, including those involving Satoyama, should urgently be promoted and adapted to local conditions (Shimpo, 2022). In this sense, the pandemic has created new opportunities for the development of Satoyama activities, which can provide stress relief for urban residents experiencing long-term distress.

SEPLS, of which Satoyama landscapes are an example, provide communities with abundant food resources, allowing residents to access agricultural products without direct monetary exchange. Via a nationwide online questionnaire survey, Saito et al. (2018) quantified the contribution of SEPL-based food-sharing services to daily life in Japan, in terms of food quantity and variety, comparing landscape types: in mountainous, semi-mountainous, and flatland agricultural areas, 16% of the total food supply came from non-market sources, whereas in urbanized areas only 10% came from such sources. On average, non-market sources supplied 32–34 different types of food, with no significant differences among agricultural landscape types, including urbanized areas with limited farmland. Vegetables were the most common items supplied by non-market sources. The areas of farmland and forest were significantly positively correlated with the quantity of most of the non-market food items, but not with the range of food types available. As land development increased, the supply of food from non-market sources tended to decline (Saito et al. 2018).

In addition to nationwide surveys, local-scale studies are useful to provide detailed

insights. Based on a survey, people living in Satoyama-based rural villages and Satoumi-based fishing villages on the Noto Peninsula obtained far more food from their semi-urban from home gardens, wild harvesting from forests and marine environments, and food-sharing services than those in semi-urban communities, in terms of both quantity and variety. They were thus able to maintain their nutritional intake while reducing their household expenses. In Satoumi-based fishing villages, households saved 119,881 JPY annually, the highest among these three socio-geographical communities (Kamiyama, 2020). Although these three community types did not differ in numbers of food-sharing partners, semi-urban communities obtained the largest proportion of their food (42%) through sharing. This is largely explained by the geographic dispersion of sharing partners in semi-urban communities. Unlike in farming and fishing villages, where sharing occurs within the community, sharing in semi-urban communities relies on long-distance cross-community social networks, likely formed by residents who have previously lived in rural villages and continue to maintain ties with relatives and friends after relocating.

To further explore recent changes in household consumption patterns in Japan, Kamiyama et al. (2023) conducted a quantitative analysis of data from questionnaire surveys before and after the COVID-19 pandemic. Overall, total household food production increased after the pandemic, whereas the total volume of food sharing declined, likely owing to pandemic control measures that restricted interpersonal interactions. Nevertheless, most of the respondents reported that the pandemic did not substantially affect their household food production and sharing practices, implying that the existing household consumption

systems are resilient. Direct access to ecosystem services and the culture of food-sharing in the Satoyama and Satoumi systems both contribute to strengthening resilience toward future socio-economic changes and natural disasters. This aligns with the principle of “improved community resilience” emphasized in the six ecological and socio-economic perspectives of the Satoyama Initiative, generating multiple benefits across ecological, social, cultural, and economic dimensions, particularly through ecosystem-based climate change mitigation and adaptation strategies.

The energy crisis exposed by the Great East Japan Earthquake on March 11, 2011, is relevant in terms of resilience. The accident at the Fukushima Daiichi Nuclear Power Plant forced the authorities to urgently address energy-security challenges. In this context, the use of Satoyama woodlands as an energy source to achieve regional energy self-sufficiency has emerged as a potential strategy (Matsumura, 2022). The Geihoku area of Kitahiroshima Town (Yamagata District, Hiroshima Prefecture, Japan) has experienced a severe population decline, and few residents are willing to participate in restoring Satoyama landscapes. In response, a local non-profit organization was established; this organization collaborated with stakeholders to promote a recycling-oriented society, make flexible utilization of Satoyama forest resources, and achieve household energy self-sufficiency (Kamada, 2018).

Terada (2020) evaluated the potential benefits of wood biomass reserves as emergency energy sources in Oaota no Mori, Kashiwa City (Chiba Prefecture). Their study simulated a scenario in which an emergency, such as a major earthquake in Tokyo, interrupts the power supply system, with insufficient regional reserve energy. In this

simulated scenario, the improved suburban Satoyama woodlands were able to supply firewood to many nearby users and support the basic livelihoods of local residents. Given that the use of biomass to obtain energy is not widespread in Japan, urban residents should be encouraged to consistently use biomass in everyday life and to maintain emergency reserves. Progress toward a resilient society requires supportive policies and legal frameworks. Fukamachi (2020) examined the trends and mechanisms of natural resource use in Iba (Higashiomi City) and Yahata (Otsu City) in Shiga Prefecture, explaining how national and prefectural policies are applied to two distinctly different Satoyama landscapes. Establishing Satoyama ecosystems as resilient socio-ecological systems requires a well-integrated regional policy framework, facilitating horizontal collaboration among autonomous smallholder farmers, as well as efforts to explore new values of Satoyama under challenging natural environments. As illustrated in the case of Yahata, farmers tend to make individual decisions based on their own circumstances, and in the absence of a comprehensive legal framework, many Satoyama-related civic activities are implemented on a case-by-case basis. Strengthening institutional coordination could enable these active local initiatives not only to enhance sustainable management of natural resources but also to improve disaster resilience (Fukamachi, 2020). This also echoes the principle of “cyclic use of natural resources” within the six ecological and socio-economic perspectives of the Satoyama Initiative, which aim to improve regional resource utilization in normal times to avoid shortages during crises.

Challenges of Satoyama

In recent years, Japan has faced four

major biodiversity crises, which have been formally recognized in the *Japan Biodiversity Outlook* and *NBSAP*. The first originated from resource overexploitation and water pollution. Although the impact of this crisis was far-reaching, it has somewhat diminished with the decline in development and slower economic growth. The second is the reduced use and insufficient management of SEPLS, and its impact has become increasingly severe with the sharp population declines and population ageing in rural Japan. The third refers to the human introduction of invasive alien species and chemical substances, and the fourth to climate change. Alarming, climate change amplifies the effects of the other three, highlighting the need to pay close attention to particularly vulnerable ecosystems (Saito et al. 2020).

Since the late 1950s, resource use has shifted from firewood and charcoal to fossil fuels. The fossil fuel revolution brought a series of challenges and crises to the development of Satoyama landscapes (Matsumura 2022). Japan relied increasingly on imported energy sources, including petroleum, natural gas, and electricity, which rapidly met the demands of daily life and facilitated the transition to modern lifestyles. This resulted in the rapid abandonment of the abundant natural resources of Satoyama landscapes (Kamada, 2018). This is illustrated by the underutilization of natural resources that occurred in the Fujiwara area of Minakami Town (Gunma Prefecture). Around the 1950s, residents in the Fujiwara area abandoned the custom of replacing thatched roofs, because the replacement process was laborious and time-consuming. Coupled with external factors of modernization, traditional resource-use practices such as *Kayakari* and *Noyaki* gradually declined. The construction of four

dams provided local residents with paid job opportunities, causing them to abandon their previous livelihoods. The opening of railways and highways brought a continuous stream of tourists, and the grasslands that had once been surrounded by forests were subsequently converted into resorts. With the booming tourism industry, most of the residents chose to work in the accommodation and catering industries (Hirahara, 2020), and the practice of obtaining fertilizers, fodder, and other necessities from the fields has since become rare. The grasslands have gradually been abandoned, and invasions of alien species were documented in 2000 (Hirahara, 2020).

A similar trajectory was observed in Kosuge Village in Kitatsuru District, Yamanashi Prefecture, Japan. In this remote mountain village, 95% of the area was originally covered by secondary forests and artificial coniferous forests. However, after the widespread adoption of liquefied gas, consumption of firewood and charcoal decreased significantly, leading to the abandonment of pine and oak coppice forests in the early 1970s (Imai et al. 2023). In contrast, Piras et al. (2022) conducted a multi-temporal spatial analysis of data for a 20-year period; this revealed that while the Satoyama landscape shrank by 50.5 ha, owing to the loss of igune landscapes and other small woodlands, 34.3 ha of new Satoyama landscape were added, mostly due to agricultural abandonment and secondary succession, thereby sustaining it.

In Japan, the primary challenge facing Satoyama is the impact of urbanization. As rural populations are increasingly drawn to urban areas, human disturbance of the natural environment declines. This in turn threatens the development of Satoyama landscapes, which require regular human management to support biodiversity and to provide benefits

for humans (Dunbar and Yanagiya, 2024).

After World War II, Japan's reconstruction and rapid economic growth drove a steady surge in demand for construction timber (Kamada 2018). Since 1950, forest policies in Japan have promoted the large-scale planting of Japanese cedar (*Cryptomeria japonica*), cypress (*Chamaecyparis obtusa*), and pines to supply large quantities of timber. These monoculture plantations have replaced the original high-biodiversity natural forests. The dense canopy shade created by these plantations negatively affects rice cultivation in Satoyama landscapes, while in remote areas, plantation-thinning operations often have low economic efficiency (Sehra and MacMillan, 2021). In Fukushima Prefecture, farmers cultivating rice in Satoyama landscapes have indicated that the cedar trees on the surrounding mountains were planted through afforestation programs. As plantations have expanded and natural forests declined, the availability of food resources for wildlife in mountainous areas has declined. Consequently, in order to survive, wild boars increasingly descend into agricultural fields in search of food (Sehra and MacMillan 2021). The Satoyama landscape has gradually shifted from being a vibrant, diverse mosaic of natural forest patches into a single-function plantation forest, jeopardizing the ecological balance that had been maintained for generations.

In 1964, Japan liberalized the timber trade, allowing the large-scale import of cheap timber from overseas. At the same time, the rural depopulation and rising labor costs associated with economic growth created combined pressures, leading to the abandonment of extensive forestland, including of plantations established through afforestation programs. Japan's timber self-sufficiency rate declined dramatically from

95% in 1955 to only 28% in 2013 (Kamada 2018), further undermining forest resource management in Satoyama landscapes.

With the promotion of modernized agricultural production in Japan, agricultural machinery, agrochemicals, and chemical fertilizers have been introduced, leading many farmers to abandon traditional farming methods (Kamada 2018). Under demographic and socio-economic pressures, farmers often choose to abandon farmland or rely more heavily on chemicals, rather than adopting wildlife-friendly farming practices. Although extensive efforts have been made in recent years to reduce the use of chemical fertilizers and pesticides, farmers may still rely on them under unfavorable weather conditions or during periods of labor shortages (Sehra and MacMillan 2021).

Traditionally, Satoyama landscapes in Japan have been shaped by smallholder farmers through the intelligent use of their land and the surrounding natural environment, thereby ensuring biodiversity and fostering unique local cultures. Today, rural communities in Japan are facing severe challenges, forcing farmers to adopt alternative management strategies, consolidate farmland, and implement standardized mechanized production systems (Fukamachi 2020). Similarly, with the expansion of agricultural mechanization, there has been an increasing shift from multi-cropping systems to monoculture cultivation (Kohsaka et al. 2013). Modernized agricultural production involves changes in farmland use patterns. In the Minabe–Tanabe Ume System in southern Wakayama Prefecture, with the ageing of farmers and policy developments in the national agricultural sector, farmers have shifted to planting the plum orchards on the relatively flat terrain created through land excavation

and filling or on converted rice paddies, causing a rapid increase in the abandonment of traditional slope-type plum orchards. In order to manage these abandoned slopes, the local government prioritized artificial afforestation with *Quercus phillyraeoides*, from which charcoal could be produced. However, owing to the shift away from slope-based farming and the increase in sudden landslides, all farming in this area had to stop, and the land was redesignated as a national landslide-protection forest. These changes, which have accelerated the shift from traditional farming methods, threaten the balance of the dynamic land-use system comprising plum orchards, forests, and other land uses (Hara et al. 2021).

In the Satoyama landscape of Yahata, Otsu City, the traditional stone and earthen embankments of rice terraces have a long history. However, since the 1990s, efforts to reduce the amount of maintenance work required (such as weeding) have led to large-scale slope modification, and many traditional embankments have been replaced with concrete (Fukamachi, 2020). Although infrastructure improvements have helped to sustain agriculture in hilly and mountainous areas and in economically disadvantaged regions, the number of plant species recorded in the improved farmland is substantially lower than in the traditional farmland, reflecting its reduced ecological value (Fukamachi, 2020). In some rural areas, agricultural modernization and mechanization have led to the establishment of monocultures, resulting in a sharp decline in biodiversity (Kohsaka et al. 2013).

Since the 1960s, the rapid industrial growth in Japan has generated numerous job opportunities, attracting rural populations towards cities. Consequently, rural areas have experienced population out-migration

and aging, resulting in a sharp decline in the agricultural, forestry, and fisheries labor forces (Kamiyama, 2020). Iwata et al. (2014) conducted an online survey among individuals who had not participated in Satoyama-related activities. Among other questions, the participants were asked, “If you would like to live in a rural area but cannot do so, what would prevent you from doing so?” The top three answers were “unable to leave my current job”, “few shopping options”, and “no interesting jobs”. These responses all reflect practical constraints, and young people aged 20–40 tend to express these views. The appeal of urban lifestyles has drawn many young Japanese people into metropolitan areas, and very few are willing to remain in remote areas to work in low-paying food production jobs. Consequently, a growing disconnection has emerged between Japanese people and their food production systems (Sehra and MacMillan 2021). Based on a study on farmland abandonment, the lack of successors for ageing farmers and the aging of rural populations have led to declining productivity in rice terrace systems (Sarker 2020). In the Minabe-Tanabe Ume System, population ageing has resulted in the abandonment of an increasing number of plum orchards, prompting local forestry authorities to initiate afforestation on abandoned slope-type orchards (Hara et al. 2021). In several regions of Japan, including Kanto, Chubu, Chugoku, and Shikoku, farmland abandonment is positively associated with steeply sloped paddy fields, as elderly farmers are unable to farm on such slopes. In remote areas of Fukushima Prefecture, the effects of population ageing are becoming more pronounced. Farmers have more land than they can effectively manage, but no successors willing to take over; as a result, they continue farming, but using chemicals

rather than labor (Sehra and MacMillan 2021). Although Japan’s agricultural policy is providing support to commercial farms through subsidies, loans, and financing to address labor shortages, these measures alone are insufficient to fundamentally alter the labor structure or ensure the long-term sustainability of rice production (Sehra and MacMillan 2021). When designing land-use strategies to support avian diversity, socio-ecological factors, such as the ageing farming population and rural depopulation, must be considered (Katayama et al. 2021). Even in some plain areas, the number of abandoned small-scale farmland plots has continued to increase. Katayama et al. (2021) suggest combining abandoned farmland plots into productive landscapes, thus providing birds with habitats that resemble natural wetlands.

Environmental knowledge is not easily disseminated into rural areas. Farmers who want to learn and implement environmentally friendly practices are constrained by the lack of an appropriate communications platform for knowledge exchange. Although the government and agricultural authorities frequently emphasize the importance of organic agriculture and biodiversity, farmers remain uncertain about how to address the difficulties they face (Sehra and MacMillan 2021). The mechanisms for sharing non-market food and the social networks that sustain them are gradually weakening. With the absence of younger generations in rural and fishing communities, it is becoming increasingly difficult to transmit traditional knowledge and associated skills through the medium of food-related practices, culture, or customs. The numbers of edible plants growing in mountain forests have declined sharply, and long-established lifestyles are likely to collapse, thereby increasingly threatening SEPLS (Kamiyama 2020).

Kamiyama et al. (2023) analyzed data obtained using two online questionnaires on rates of household food consumption from non-market exchanges in Japan, finding that those respondents who said that they participated in non-market exchanges were predominantly elderly. This survey revealed a decline in household non-market food consumption; although this decline was less pronounced than predicted by some earlier studies, it nevertheless warrants concern (Kamiyama et al. 2023). In the absence of proactive policy interventions, this decline is likely to persist. Owing to agricultural transformations and the westernization of Japanese food, Japanese people now rarely eat domestically produced white rice (Sehra and MacMillan, 2021), and most are uninterested in the abundant food resources of Satoyama landscapes. Changing dietary habits in Japan have affected people's physical health, resulting in particular in chronic diseases associated with obesity (Kamiyama et al. 2023).

Between 1955 and 1975, Japan experienced rapid industrial expansion and high levels of economic growth, with its cities attracting large numbers of rural residents in search of employment. Within a short period, the cities absorbed large populations, particularly in the three major metropolitan regions of Tokyo, Osaka, and Nagoya, where limited land availability within the urban core made outward expansion inevitable (Kohsaka et al. 2013). With the outward expansion of cities, extensive Satoyama landscapes were incorporated into urban land and converted into residential areas, with land ownership transferred to local governments. The urban residents living around Satoyama landscapes were given few opportunities to participate in decision-making, and the land-use changes around these sites effectively eliminated their

surrounding Satoyama landscapes (Kamada 2018).

In addition to agricultural intensification, urban expansion poses a serious threat to biodiversity, particularly by leading to landscape fragmentation (Piras et al. 2022). Yokohama City, in eastern Kanagawa Prefecture, is the second largest city in Japan after Tokyo. During the period of rapid economic development in the 1970s and 1980s, Yokohama City experienced a large influx of migrants, and its area of natural land decreased as the population grew. According to the statistics of the Environmental Planning Bureau of Yokohama City for 2013, the city's green-coverage rate dropped sharply from 50% in 1970 to 29.8% in 2009; many green spaces, including areas that had once been Satoyama landscapes, were lost to development and construction, and these landscapes were only partially preserved (Iwachido et al. 2020). In urban areas in Japan, agricultural land is mostly owned and managed by private landowners, and this has been the case for more than a century. The woodlands are dominated by deciduous broad-leaved forests, from which timber and wood fuel are obtained through thinning, while pests that restrict crop growth are eliminated through weeding. Satoyama landscapes typically feature hilly land and small stream valleys formed by water erosion. Today, however, many of these landscapes have been incorporated into urban areas and converted into parks, citizen forests, and other land uses, resulting in the loss of some traditional Satoyama ecosystem functions (Iwachido et al. 2020). Urbanization weakens the community ties and sharing mechanisms that support non-market food supply, especially in densely built urban environments, thereby reducing resilience to future socioeconomic changes and natural

disasters (Saito et al. 2018).

Population ageing is a key problem, not only in rural Satoyama landscapes, but also in large cities and the surrounding peri-urban areas. Ensuring an appropriate labor force to maintain the productivity of ecosystem services has thus become a top priority (Kohsaka et al. 2013). Shimpo (2022) reviewed Satoyama-conservation activities among urban residents in the Tokyo metropolitan region, finding that most of the participants in these activities were retirees aged over 60. In contrast, young people are typically busy with work and family life and are generally limited to participating in one-day activities. An ageing demographic such as this poses a challenge to the sustainability of routine conservation activities (Shimpo 2022). Similarly, the aforementioned study by Hino et al. (2023) revealed that, among various activity types in productive urban landscapes, woodland-related activities attracted the second-oldest participants (average age, 70.6 years). Participants over 70 years old frequently visited these productive urban landscapes and participated in related activities. Concerningly, population ageing may lead to a growing shortage of individuals capable of managing productive urban landscapes.

In recent years, global climate change has become a key factor affecting the survival of native species and the balance of species communities, transforming the entire ecosystem of Satoyama landscapes (Kohsaka et al. 2013). Invasive species may take advantage of landscape fragmentation or reduced habitat connectivity to invade Satoyama landscapes, thus profoundly affecting the natural communities (Piras et al. 2022). Iwachido et al. (2020) studied the nature-oriented parks of Yokohama City (Kanagawa Prefecture), hypothesizing that

artificial structures such as paved sidewalks, playgrounds, and rest areas might increase the likelihood of alien species invasion; however, field investigations revealed that alien species invasions did not increase with the number of constructed areas. This finding is related to the fact that parks are naturalized areas with relatively high disturbance intensity in urban landscapes, with native plant species occupying complementary niches, thus limiting invasion by alien species (Iwachido et al. 2020). Similarly, in excavated and refilled plum orchard systems, nitrogen-fixing plants are often introduced to facilitate rapid greening, while conventional farming practices frequently use alien species to generate green manure or nectar for pollinators. However, Hara et al. (2021) found no significant differences between modified orchards and traditional plum orchard systems in the occurrence of alien species. Although these two studies did not reveal clear evidence of invasion, its risks should not be overlooked, and further research is required to clarify the underlying relationships.

Climate change is influencing wildlife-friendly farming practices within Satoyama landscapes, and this may negatively affect Japan's rice production systems in future (Sehra and MacMillan 2021). Rice farmers surveyed in the Fukushima, Tochigi, and Chiba Prefectures responded that the temperature "has never risen so high so quickly" and that weather patterns are changing rapidly. Consequently, the impacts of climate change need to be incorporated into policy analysis and economic assessments to support the sustainable production of high-quality rice in Satoyama landscapes (Sehra and MacMillan 2021).

Furthermore, in response to climate change, societies are reducing fossil fuel consumption and transitioning toward

renewable energy. However, the land required for renewable energy development is increasingly encroaching upon Satoyama landscapes. Based on a land-use layer intersection analysis for the period 2002–2021, Piras et al. (2022) observed relatively minor land-use changes in igune and other small forest patches over the period, with a net reduction of just 16.2 ha. Notably, the largest proportion of this loss was due to the expansion of solar panel installations, accounting for 44% of the lost area, followed by agricultural expansion (22%) and urban expansion (11%).

More recently, solar panel development has expanded into the Minabe–Tanabe Ume System, where the vegetation has been removed or farmland converted to accommodate energy infrastructure. Recognizing the potential threat to traditional plum orchard landscapes, the Wakayama Prefectural Government has begun actively promoting regulatory measures to prevent the excessive development of plum orchards (Hara et al. 2021).

CONCLUSIONS

This review of the recent international literature on Satoyama landscapes broadens the conceptual understanding of these landscapes and clarifies the developmental context. As we move toward the next generation of researchers while maintaining biodiversity and nature's contribution to humanity, we need to continue engaging with, and learning within, Satoyama landscapes, with the aim of creating a new set of values. The main conclusions of this review are as follows:

1. A widespread misconception equates Satoyama solely with forests. In fact, Satoyama landscapes comprise multiple interconnected elements, including forests, rice paddies, grasslands, lakes, and ponds, all of which play equally important ecological roles. Such a misconception hinders the promotion of landscape-scale environmental conservation, highlighting the need to enhance public understanding of Satoyama through environmental education.
2. The dynamic mosaic landscape characteristic of Satoyama relies on appropriate human management. Therefore, farmland abandonment should be minimized. Otherwise, unchecked vegetation succession and increasing wildlife populations may lead to more frequent environmental disturbance and ongoing biodiversity decline.
3. Whether in rural regions, peri-urban areas, or urban green spaces, participants in Satoyama activities are predominantly elderly, indicating that population ageing poses a growing challenge to Satoyama conservation. Identifying more diverse participation opportunities is therefore necessary to encourage broader public engagement across different social groups.
4. Young people, and particularly urban students, remain among the least engaged with Satoyama landscapes, often showing limited awareness of the cultural values embedded in nearby Satoyama environments. Nevertheless, they also represent a group with significant future potential. Encouraging younger generations to re-engage with Japan's agricultural production systems and rebuilding interactions between people and Satoyama landscapes are therefore important challenges.
5. In Satoyama-based communities, disaster resilience must be grounded in the sustainable use of natural resources during normal periods. Food-sharing traditions represent an important component of such resilience. These practices reflect

traditional knowledge related to the sharing of ecosystem-based provisioning services. Although largely intangible, such knowledge can only be maintained and transmitted through repeated practice in everyday life.

RECOMMENDATIONS AND LIMITATIONS

Drawing on international experiences in Satoyama landscape management, this study proposes recommendations tailored to Taiwan's local context. Based on this assessment of the current challenges in the development of Satoyama landscapes in Taiwan, three recommendations are proposed:

1. Government agencies should establish a regional-scale governance framework for Satoyama management. Within an appropriately flexible regulatory environment, short- and medium-term economic support should be provided to Satoyama landscape managers through policy instruments such as subsidies, incentives, tax reductions or exemptions, and low-interest loans. Such support would help to create opportunities for ecological and agricultural recovery, thereby enabling the long-term development of Satoyama landscapes. In addition, particular attention should be given to the highly productive lowland areas within Satoyama landscapes. Once these areas become abandoned or idle, their restoration becomes considerably more difficult. Economic incentives provided by the government could encourage farmers to resume and maintain at least a minimal level of cultivation.
2. Given the ageing demographic of current Satoyama participants and the labour shortages faced in many rural areas, it is essential to broaden participation in

Satoyama activities. Students and young people represent a particularly important potential group. Under Taiwan's *12-Year Basic Education Curriculum Guidelines* (the 108 Curriculum), teachers are increasingly adopting competency-based and place-based learning approaches. Satoyama landscapes provide valuable educational resources that can be integrated into local studies, subject-based learning, environmental education, outdoor education, and inquiry-based learning. These approaches may help students re-establish their connection with Satoyama through everyday learning experiences. Educational activities do not necessarily need to focus on well-known Satoyama sites in Taiwan, such as the Gongliao terraced rice fields in New Taipei City, the homegardens in the mountainous areas of Pingtung County, or the forest–river–village–sea landscape of Xinshe Village, Fengbin Township, in Hualien County. Instead, Satoyama environments located near homes or schools may better reflect the spirit of the Satoyama Initiative. Furthermore, Satoyama activities should not be limited to environmental conservation advocacy. Diverse forms of engagement, such as photography, sketching, picnics, community markets, light travel experiences, handicraft workshops, forest therapy, and ecological interpretation activities, may increase public engagement and enhance awareness of the ecological and cultural values of Satoyama landscapes.

3. Taiwan and Japan share similar environmental conditions, characterized by extensive mountain ranges, frequent earthquakes, and recurring typhoon impacts during summer and autumn. These factors often result in environmental

disasters of varying severity. Under such circumstances, natural resources within Satoyama landscapes can provide important support. For example, residents may rely on locations where wild edible plants can be harvested, firewood collected for heating or cooking, and clean water obtained. These resources can temporarily help affected residents to sustain themselves, contributing to local disaster resilience. However, disaster resilience depends on the regular and sustainable use of these natural resources during normal periods, as well as the transmission and application of local ecological knowledge. Routine practices such as pruning trees, collecting organic fertilizers, sharing food resources, and maintaining irrigation channels help to sustain the Satoyama system. Without such practices, Satoyama ecosystems may gradually degrade, ultimately reducing both ecological integrity and human well-being.

Several limitations of this study should be acknowledged. First, to maintain a clear focus on the research topic, only the term *Satoyama* was used as the primary keyword in the literature search, so the electronic databases returned primarily publications that explicitly used the term *Satoyama*. However, some studies may fall within the conceptual scope of Satoyama research without directly employing this term. Related studies may use alternative expressions such as traditional rural landscape in Japan or traditional Japanese rural landscapes; traditional agricultural landscape in Japan or traditional Japanese agricultural landscape; original landscape of the Japanese; a landscape with mosaics; or Socio-Ecological Production Landscapes and Seascapes (SEPLS). Such studies are also closely related to the Satoyama concept. Second, although the relevant literature was collected through

electronic databases and recent journal articles were screened, it is possible that some important studies were not included in the review.

Finally, all of the articles included in this study were written in English, and Japanese-language publications were not incorporated. Researchers who wish to conduct more in-depth studies on Satoyama may therefore benefit from consulting the Japanese-language literature, as such sources may provide additional insights into the topic.

LITERATURE CITED

- Bhatt A, Kumar NA, Dhanya CS, and Vipindas P. 2023.** Restoring Rice Paddies and Rice Agro-Ecosystem Services Through a Participatory Seed Conservation and Exchange Programme. In Nishi, M., and Subramanian, S.M. (eds) *Ecosystem Restoration through Managing Socio-Ecological Production Landscapes and Seascapes (SEPLS)*. Satoyama Initiative Thematic Review. Singapore: Springer Singapore. pp. 53-74.
- Dunbar W, and Yanagiya M 2024.** Satoyama. In Sarmiento, F.O., and Gunya, A. (eds) *Mountain Lexicon*. Montology, vol 2. Cham: Springer Cham.
- Fukamachi K. 2017.** Sustainability of terraced paddy fields in traditional Satoyama landscapes of Japan. *J of Environ Manage* 202(3) 543-49. <https://doi.org/10.1016/j.jenvman.2016.11.061>
- Fukamachi K. 2020.** Building resilient socio-ecological systems in Japan: Satoyama examples from Shiga Prefecture. *Ecosyst Serv* 46:101187. <https://doi.org/10.1016/j.ecoser.2020.101187>
- Hara Y, Oki S, Uchiyama Y, et al. 2021.** Plant diversity in the dynamic mosaic landscape of an agricultural heritage system: The Minabe-

Tanabe Ume system. *Land* 10(6):559. <https://doi.org/10.3390/land10060559>

Hino K, Yamazaki T, Iida A, Harada K, and Yokohari M. 2023. Productive urban landscapes contribute to physical activity promotion among Tokyo residents. *Landscape and Urban Planning* 230:104634.

Hirahara S. 2020. Regeneration of underused natural resources by collaboration between urban and rural residents: A case study in Fujiwara district, Japan. *Int J Commons* 14(1):173-90. <https://doi.org/10.5334/ijc.977>

Imai N, Otokawa H, Okamoto A, et al. 2023. Abandonment of cropland and seminatural grassland in a mountainous traditional agricultural landscape in Japan. *Sustainability* 15(10):7742. <https://doi.org/10.3390/su15107742>

Iwachido Y, Uchida K, Ushimaru A, Yokota S, and Sasaki T. 2020. Nature-oriented park use of Satoyama ecosystems can enhance biodiversity conservation in urbanized landscapes. *Landsc Ecol Eng* 16:163-72. <https://doi.org/10.1007/s11355-020-00413-y>

Iwata Y, Yumoto T, and Morimoto Y. 2014. Can Satoyama Offer a Realistic Solution for a Low Carbon Society? Public Perception and Challenges Arising. In Nakagoshi, N., A., and Mabuhay, J. (eds) *Designing Low Carbon Societies in Landscapes*. Ecological Research Monographs. Tokyo: Springer Japan.

Kamada M. 2018. Satoyama landscape of Japan—past, present, and future. In Hong, SK., and Nakagoshi, N. (eds) *Landscape Ecology for Sustainable Society* (pp. 87-109). Cham: Springer International Publishing.

Kamiyama C. 2020. Food Provisioning Services via Homegardens and Communal Sharing in Satoyama Socio-Ecological Production Landscapes on Japan's Noto Peninsula. In Saito, O. (eds) *Sharing Ecosystem Services*. Science for Sustainable Societies (pp. 35-53). Singapore: Springer

Singapore.

Kamiyama C, Hori K, Matsui T, Pretty J and Saito O. 2023. Longitudinal analysis of home food production and food sharing behavior in Japan: multiple benefits of local food systems and the recent impact of the COVID-19 pandemic. *Sustain Sci* 18(5):2277-91. <https://doi.org/10.1007/s11625-024-01511-8>

Katayama N, Mashiko M, Koshida C and Yamaura Y. 2021. Effects of rice-field abandonment rates on bird communities in mixed farmland–woodland landscapes in Japan. *Agric Ecosyst Environ* 319:107539. <https://doi.org/10.1016/j.agee.2021.107539>

Katsuda K, Saeki I, Shoyama K, and Kamijo T. 2022. Local perception of ecosystem services provided by symbolic wild cherry blossoms: toward community-based management of traditional forest landscapes in Japan. *Ecosyst People*, 18(1):275-88. <https://doi.org/10.1080/26395916.2022.2065359>

Kohsaka R, Shih W, Saito O and Sadohara S. 2013. Local Assessment of Tokyo: Satoyama and Satoumi – Traditional Landscapes and Management Practices in a Contemporary Urban Environment. In Elmqvist, T., Fragkias, M., Goodness, J., Güneralp, B., Marcotullio, P. J., McDonald, R. I., Parnell, S., Schewenius, M., Sendstad, M., Seto, K. C., and Wilkinson, C. (eds) *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities* (pp. 93-105). Dordrecht: Springer, Dordrecht.

Kovács B, Uchiyama Y, Miyake Y, Quevedo JMD and Kohsaka R. 2022. Capturing landscape values in peri-urban Satoyama forests: Diversity of visitors' perceptions and implications for future value assessments. *Trees, Forests and People* 10:100339. <https://doi.org/10.1016/j.tfp.2022.100339>

Kurniawan T and Kurniawan E. 2022.

Policy on utilizing indigenous knowledge in critical land rehabilitation and fulfillment of sustainable food security in Indonesia: Regrowing “Talun-Kebun” as part of the local permaculture model in west java. *Environ Sci Proc* 15(1):2. <https://doi.org/10.3390/environsciproc2022015002>

Kweon D and Youn YC. 2021. Factors influencing sustainability of traditional village groves (Maeulsoop) in Korea. *For Policy and Econ* 128:02477. <https://doi.org/10.1016/j.forpol.2021.102477>

Matsumura M. 2022. The Satoyama Movement and Its Adaptability: Beyond Ideology and Institutionalization. In Miyauchi, T., and Fukunaga, M. (eds) *Adaptive Participatory Environmental Governance in Japan: Local Experiences, Global Lessons* (pp. 67-92). Singapore: Springer Nature Singapore.

Maney C, Guaras D, Harrison J, et al. 2024. National commitments to Aichi Targets and their implications for monitoring the Kunming-Montreal Global Biodiversity Framework. *npj biodivers* 3(1):6. <https://doi.org/10.1038/s44185-024-00039-5>

Nagao Y, Nishikori A, and Imoto T. 2021. The relationship between the conception of nature and environmental valuation. *Sustainability* 13(22):12683. <https://doi.org/10.3390/su132212683>

Nyongesa JM, Donatti CI and Kiptenai TK. 2023. Community-Based Rangeland Restoration for Climate Resilience and Pastoral Livelihoods in Chyulu, Kenya. In Nishi, M., and Subramanian, S.M. (eds) *Ecosystem Restoration through Managing Socio-Ecological Production Landscapes and Seascapes (SEPLS)*. Satoyama Initiative Thematic Review. Singapore: Springer Singapore.

Piras F, Fiore B, and Santoro A. 2022. Small cultural forests: landscape role and ecosystem

services in a Japanese cultural landscape. *Land* 11(9):1494. <https://doi.org/10.3390/land11091494>

Ruiz-Labrador EE, Sánchez-Martín JM and Gurría-Gascón JL. 2023. The agritourism value chain: an application to the dehesa areas of extremadura. *Agriculture* 13(11):2078. <https://doi.org/10.3390/agriculture13112078>

Saito O, Kamiyama C and Hashimoto S. 2018. Non-Market Food Provision and Sharing in Japan’s Socio-Ecological Production Landscapes. *Sustainability* 10(1):213.

Saito O, Subramanian SM, Hashimoto S and Takeuchi K. 2020. Introduction: Socio-ecological Production Landscapes and Seascapes. In Saito, O., Subramanian, S., Hashimoto, S., and Takeuchi, K. (eds) *Managing Socio-ecological Production Landscapes and Seascapes for Sustainable Communities in Asia* (pp. 1-10). Science for Sustainable Societies. Singapore: Springer Singapore.

Sarker A. 2020. Economics of underproduction: A polycentric approach for a depopulated commons in Japan. *Ecol Econ* 171:106597. <https://doi.org/10.1016/j.ecolecon.2020.106597>

Sehra KK, and MacMillan DC. 2021. Wildlife-friendly food requires a multi-stakeholder approach to deliver landscape-scale biodiversity conservation in the Satoyama landscape of Japan. *J Environ Manage* 297:113275.

Shimpo N. 2022. Urban ecological life in a metropolitan area—an insight from Satoyama conservation activities in the Greater Tokyo Area. *Landsc Ecol Eng* 18(1):109-19. <https://doi.org/10.1007/s11355-021-00484-5>

Terada T. 2020. Evaluating landscape improvement scenarios from the perspective of biomass production: a case study of peri-urban satoyama woodland in the Tokyo Metropolitan Area. *Sustain Sci* 15(5):1495-510.

Torralba M, Nishi M, Cebrián-Piqueras MA, Quintas-Soriano C, García-Martín M, and Plieninger T. 2023. Disentangling the practice of landscape approaches: a Q-method analysis on experiences in socio-ecological production landscapes and seascapes. *Sustain Sci* 18(4):1893-906.

Xiang Q, Yuan Z, Furuya K, and Kagawa T. 2022. Verification of psychophysiological effects of Satoyama activities on older adult volunteers and young people in post-COVID-19 society: A case study of Matsudo City, Japan. *Int J Environ Res Public Health* 19(17):10760.