

Original Research Article

Revitalization of Japanese Mountainous Communities to Regain Sustainability based on Five Drivers of Circularity: A Case study of Kamanuma Community *

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Abstract | Japanese mountainous communities with terraced rice fields, once sustained through resource circulation and self-sufficient local systems have undergone substantial transformations since the postwar period. Depopulation, aging, and structural changes in rural economies have undermined their traditional sustainability, leading to weakened agricultural capacity and reduced community resilience. This paper aimed to understand how those mountainous communities can regain their sustainability through rural revitalization and activation of a resource-oriented farming based on the circulation of resources. An analytical framework called the five drivers of circularity was utilized for this research to clarify the specific and contextual drivers of circularity drivers in the Kamanuma community as a case study. Data were collected through semi-structured interviews with local farmers, and the analysis followed a thematic approach. Findings show that the natural resource driver forms the foundation of Kamanuma's circular system. Traditional Tensui (rain-fed) rice farming, the repurposing of rice straw for tools, fertilizer, and handicrafts, as well as charcoal making as part of the Satoyama lifestyle, were identified as key components of resource-oriented farming in the village. These practices support a localized food system in which rice and processed food goods circulate within the community, contributing to multifunctionality, self-sufficiency, and enhanced value for residents and visitors. The knowledge and skills driver highlights the existence of a local network that facilitates agricultural cooperation, knowledge exchange, and the continuation of traditional practices within and beyond the community. However, the study also reveals that the long-term sustainability of Kamanuma depends heavily on securing human resources to maintain terraced farming. Given that farming alone is not financially viable, continuous urban-rural exchange programs, where volunteers from urban areas provide labor and support, play a crucial role in sustaining agricultural activities and enabling resource circulation. Accordingly, balancing urban-rural exchanges with other drivers is fundamental to the functioning of Kamanuma as a whole and to the sustained human-landscape interactions that can contribute to landscape preservation.

Keywords | Five drivers of circularity, Terraced landscapes, Sustainability, Mountainous rural communities

Introduction | Historically, terraced landscapes are recognized not only as sustainable and multifunctional land management systems, but also as reflections of human perceptions of nature, shaped through a long-standing, lived, and interactive relationship between people and the natural

environment (Abarghouei Fard & Saboonchi, 2020). These landscapes can be understood as living systems that include agricultural biodiversity, resilient ecosystems, traditional farming practices, and, most importantly, a cultural identity that reflects the rural landscape formed through continuous interactions between human activities and landscape elements such as villages, forests, and other components (Hosseinzadeh et al., 2024; Gravagnuolo & Varotto, 20). More importantly, a great track of resource circulation can be seen in such terraced landscapes around the world, particularly in hilly and mountainous regions. Italian mountainous villages around

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the Alps are good examples showing a harmonious lifestyle and sustainable agriculture in the past. Italian terraced landscapes are regarded as significant traditional landscapes, showcasing a wealth of cultural diversity and agrobiodiversity through sustainable land-use practices (UNESCO World Heritage Centre, 2013). Practices like dry stone walls and other practices by using natural resources illustrate a variety of advanced survival techniques and environmental management strategies, as well as “Clottin”, a natural rock-based refrigeration system using spring water to cool dairy products, an early example of circular and regenerative resource use in traditional mountain agriculture (Bocco & Cavaglia, 2015). Furthermore, the Scandinavian system, known as the “infield-outfield system,” was a traditional agricultural practice used in Scandinavia when different resources circulated between the infield and outfield through crop production and animal husbandry (Berglund et al., 2014). Most importantly, traditional farming in Japanese mountainous regions relied on the sustainable use of natural resources from Satoyama (literally meaning villages near mountains), which is a Japanese traditional rural landscape where agriculture and forestry were integrated with natural ecosystems (Fukamachi et al., 2001; Hirota et al., 2020). Historically speaking, before the fossil fuel revolution, farming was based on resource circulation, and locals were largely self-sufficient, producing their own fuel such as firewood and charcoal, food, building materials, and resources for agricultural tools and fertilizers. This landscape was shaped by agricultural practices and the use and management of forests and different resources, which created a sustainable and self-sufficient system. (Horiuchi et al., 2006). However, all of these traditional landscapes, which had sustainable land management systems, underwent significant changes after modernization and industrialization, both in their physical structure and, more importantly, in the identity and character of the villages (Majidi et al., 2025). Considering the depopulation and loss of sustainability in hilly and mountainous regions in Japan, it is necessary to see how those landscapes can regain their sustainability. Many countries, including Japan, have actively addressed rural decline through rural revitalization movements and renewal initiatives. These efforts aim to enhance the attractiveness of rural areas and promote urban-rural integration (Wang & Tan, 2018). In fact, the process of landscape beautification is fundamental to the production of place-based values that appeal to urban populations and, in turn, actively shape landscape perception (Mansouri, 2013). In this study, rural revitalization is understood as a comprehensive process that addresses population decline, economic stagnation, social weakening, and related challenges in an integrated manner. Within this broader framework, landscape revitalization refers specifically to the revitalization of terraced rice field landscapes (Tanada Hozon in Japanese), which function as defining features of mountainous rural communities and embody multiple social,

cultural, and ecological values. Agricultural revitalization is therefore positioned as a key mechanism within this system, as the continuation and renewal of agricultural practices are essential for sustaining these landscapes and enabling the overall revitalization process to function cohesively.

Given this background of resource circulation in terraced rice fields, it is important to explore how mountainous communities can regain sustainability through revitalization based on resource-oriented agriculture and other circulation practices. Such revitalization should be assessed multifunctionally, beyond material outcomes, to effectively support sustainability. In order to do that, this research has utilized a framework called the five drivers of circularity, which proposes five drivers for the circular regeneration of abandoned terraced landscapes (Gravagnuolo & Varotto, 2021). By utilizing this model, therefore, this research objective is to clarify community-based circular practices in the Kamanuma community and their role in achieving sustainability.

This research makes several contributions to landscape studies; however, its most significant contribution lies in clarifying the role of resource management in preserving landscapes as a prerequisite for long-term sustainable development. Although the study focuses on resource management within the context of rural revitalization and agriculture, the conceptual lens developed here can be applied to other contexts. This perspective is particularly important in countries such as Iran, where severe water shortages and related environmental challenges require more integrated and sustainable approaches to resource use. Therefore, this research aims to provide a clearer and more systematic framework for resource management that integrates a multidimensional perspective and practical insights that can guide not only landscape revitalization efforts but also broader strategies for achieving long-term sustainability in resource-constrained regions.

Literature Review

This section reviews studies on the circular economy and resource circulation, highlighting the contribution of this research. The literature is grouped into two strands: (1) theoretical and conceptual frameworks of the circular economy, and (2) local, community-based traditional practices, particularly in rural and mountainous areas in Japan and other regions. The concept of a circular economy, popularized by the Ellen MacArthur Foundation, is defined as a closed-loop system in which raw materials, components, and products retain their value and quality for as long as possible (Ellen MacArthur Foundation, 2013). Transitioning to a circular economy requires changes across multiple domains, including resource efficiency, product design, waste management, and consumer awareness (Ghisellini & Ulgiati, 2019; D'Amato, 2021). While circular economy practices have often been applied at larger scales, such as in cities, including strategies for waste reduction, re-

localization of production, and regeneration of abandoned buildings in port cities (Gravagnuolo et al., 2019). However, in Japan, the concept of waste management and natural resources circulation has a deep-rooted history before the invention of this concept, as Japan had recognized the importance of efficiently utilizing resources and minimizing waste to ensure a sustainable environment and economy. Historically, a notable example of such systems can be found in the Edo period. For example, based on Aizu Nōsho (a notebook written in 1684 by Sase Yojiemon), researchers have examined how farmers in the Aizu region practiced a “resource-circulation type life,” maintaining a harmonious coexistence with nature (Oga et al., 2010). Narrowing this down to a smaller scale, in mountainous regions, traditional farming systems relied on sustainable use of natural resources from Satoyama (villages near mountains), where agriculture and forestry were integrated with natural ecosystems (Fukamachi et al., 2001; Hirota et al., 2020). These practices fostered harmonious, self-sufficient, and sustainable community-based systems grounded in resource circulation (Takeuchi et al., 2003; Takeuchi et al., 2015).

Having said that, the following are some papers that go beyond the concept of circular economy and adopt a more context-based approach on a local scale, providing more insights into the application of circular economy practices within smaller scales, particularly in mountainous regions. Gravagnuolo & Varotto (2021), in research called Terraced Landscapes Regeneration in the Perspective of the Circular Economy, “worked on recovery practices for terraced landscapes by clarifying different local circular practices in different case studies. Regarding modern local circular systems, only a few studies have explored traditional resource-recycling lifestyles within rural communities (Oga et al., 2007, 2009). This shows a notable gap in research on practical applications and case studies of community-based circular practices, particularly in the mountainous regions of Japan. Existing these few studies tend to focus primarily on material resource circulation, overlooking a more comprehensive and multifunctional perspective. This research addresses these gaps by examining community-based circular activities through five drivers of circularity, aiming to provide a more multifunctional perspective on resource circulation and a deeper understanding of how such communities can enhance their sustainability.

Research analytical framework: Five drivers of circularity

This section presents an analytical framework based on the five drivers of circularity to examine resource circulation and support the regeneration of abandoned terraced landscapes (Gravagnuolo & Varotto, 2021). It analyzes how each driver functions in the case study, how they interact, and how they contribute to restoring sustainability. As explained in the introduction, five circular drivers include 1-Natural Resources Circularity, 2-Food, 3-Knowledge and skills, 4-Tourism, and 5-Urban-rural policies circularity, which will be utilized for this

purpose. The following explains briefly about the definition of each driver and how they were utilized in this research. Natural resources circularity maximizes economic growth by optimizing resource use, reducing environmental pressures, and, more importantly, closing resource loops in all economic activities (Hislop & Hill, 2011). A circular economy can be driven in the food and agriculture sector by relocating agricultural production and consumption. Production of local agricultural products has always been of great importance because it promotes the local economy, helps build community, and, most importantly, preserves the traditional food-production-consumption system (Gravagnuolo & Varotto, 2021). The concept of circular tourism is a method of creating goods and services sustainably, without wasting the limited resources available (Nedyalkova, 2018). Knowledge and skills circularity will examine the synergy between farmers, architects, enterprises, and third parties, as well as how the knowledge and skills transfer is circulated within the community, or further if applicable. (Donadieu, 2013). Urban-rural policies circularity refers to the initiatives and measures taken in rural areas, including social, economic, and environmental. In this research, this driver was specifically used to see how and whether urban-rural exchanges contribute to the sustainability of mountainous communities in Japan. (Salvia et al., 2018). In this study, each of these drivers will be analyzed according to interview findings to better understand what role each driver plays in the sustainability of terraced landscapes in Japan.

Materials and Methods

This study used semi-structured interviews with farmers in Kamanuma. Sampling was conducted using the snowball method, and participants were selected based on their familiarity with agriculture, the process of agricultural revitalization,

Table 1. The locals interviewed in this research along with their demographic information. Source: Authors.

Pseudonyms	Age	Gender	Date of interview
A	41	M	From July 2022 to August 2022
B	54	M	
C	75	F	
D	90	M	
E	57	F	
F	61	M	
G	52	M	
H	47	F	
I	63	M	
J	63	F	
K	65	M	

and community-based activities. Due to the limited number of residents, many having left, been hospitalized, or passed away, a total of 11 locals could be interviewed (Table 1). All interviews were conducted in-person in the village between July and August 2022 and took approximately 50–60 minutes. The interviews' content contained different questions about overall community-based circular activities, resource-oriented farming, currently after revitalization and any others available in the past. Interviews were conducted in Japanese, recorded, and then transcribed verbatim. Afterwards, the data was translated into English. To ensure data accuracy, interview data were collected with the help of Japanese scholars and reviewed carefully. For data analysis, a thematic analysis was used to examine the narratives of residents and identify recurring themes related to resource-circulating activities in Kamanuma. For this purpose, important parts of data, usually phrases and sentences, were highlighted to come up with shortened parts which are called coded data. These codes were then used to extract themes of community-based activities, which were further categorized under the five drivers of circularity defined in this study's analytical framework. Basically, each coded sentence was assigned one theme. For example, statements such as (1) "We use rice straw to make handicrafts" and (2) "I use unripe mandarins to prepare syrup, jam, and sauce" were reviewed and categorized into specific themes. The first

statement was classified under 1-Natural resource circularity, 2-and the second under food circularity. This process was applied to all interview data to ensure that each piece of information was assigned to its relevant driver. Finally, after analyzing all five drivers, the study presents a final resource circulation model for achieving sustainability in Kamanuma.

Study Area

This section outlines the Kamanuma community, its characteristics, demographic information, changes in agriculture, and an outline of revitalization. Kamanuma is a rural community in Japan, Chiba Prefecture, Kamogawa City, located in a hilly, mountainous region characterized by steep slopes and terraces (Fig. 1). Field interviews indicate Kamanuma began depopulating in the 1960s and is now a marginalized village, with around the current 23 households and approximately 60 residents, most of whom are over 60 years old. Kamanuma is surrounded by Satoyama landscape, which is a traditional land-use system combining forest, rice paddies, rich biodiversity, and a village. One of the defining characteristics of this region is terraced rice fields (Tanada in Japanese). Terraced rice fields are small in size, with different plots ranging from 0.1 to 0.5 hectares, making agriculture small-scale in Kamanuma. In 1999, a young and educated immigrant moved to Kamanuma with a vision of preserving terraced

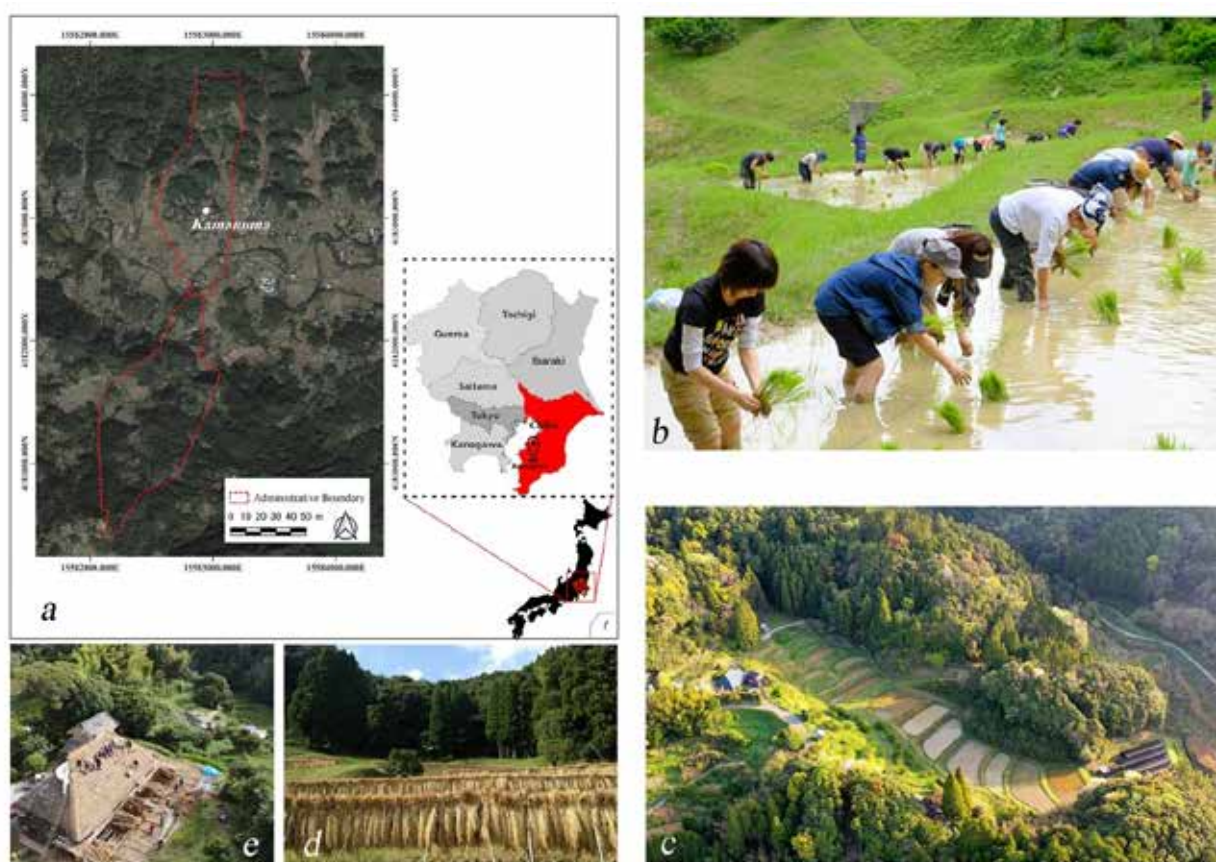


Fig. 1. A snapshot of Kamanuma community. a: positioning of Kamanuma community in map. b: Rain-fed rice paddies called Tensui as traditional way of growing rice. c: Revitalized terraced rice paddies from top view. d: Traditional way of drying rice by putting on rice rack. e: rethatching roof called Kayabuki as a community-based activity. Source: a. Authors based on Google Maps, b, c, d: www.muji.net, e: Small Earth Media 小さな地球 Media, 2022.

rice fields and the landscape for future generations. Efforts initially focused on revitalizing the terraced rice fields using the community's pre-existing traditional farming. Revitalization revolved around physical restoration and maintenance of abandoned terraced rice fields, including land preparation, irrigation, and so on. The revitalization was focused on resource-oriented farming that preexisted in the community before mechanization and depopulation. Therefore, this research has chosen Kamanuma as an appropriate case to clarify the five specific drivers of circularity, which align well with this research objective.

Findings: Clarified Five Drivers of Circularity in Kamanuma

This section will explain each clarified drivers of circularity in Kamanuma based on interview findings.

• Kamanuma's natural resource circulation

Interview findings identified a traditional practice in Kamanuma known as Tensui, in which rice paddies relied solely on rainwater for irrigation (Fig. 1-b). This method represents a sustainable and self-sufficient, resource-oriented approach well suited to Japan's climate, although it requires intensive manual labor and collective effort. This pre-existing practice, which was used for revitalization, created a sustainable and resource-oriented farming method by

collecting rain for rice paddies. Rice has historically and currently been the main crop in Kamanuma, making it a monocropping region (Tansaku Chitai) focused on rice production. Farmers, therefore, repurpose rice straw as a valuable by-product for various uses.

"We have been using rice straw to create Japanese handicrafts [工芸品] and ornaments. Also, we can utilize it as a fertilizer by putting it back into the rice field. We did not waste anything in the past, particularly before mechanization and depopulation" (B, male, 54 years old).

Rice straw is returned to the loop in two main ways. First, it is used to make traditional handicrafts and agricultural tools such as baskets and sandals. For example, farmers in Kamanuma produce a traditional tool called Warabochi (藁ボッチ) to protect rice from rain and strong winds (Fig. 2-a-2). Secondly, they cut rice straw and leave it in rice paddies as it is a natural fertilizer (Fig. 2-a-3). Locals sometimes burn the rice straw and then turn it into ash to be used as fertilizer (Fig. 2-a-4). These practices show that rice straw is reused as a valuable by-product in agriculture. Interviews also reveal that farmers produce compost from rice straw, kitchen waste, rice husk, and animal manure, reducing reliance on external inputs. Specifically, locals explained how livestock farming complemented their rice-making system in the past.

Located near forests rich in bamboo and wood, Kamanuma

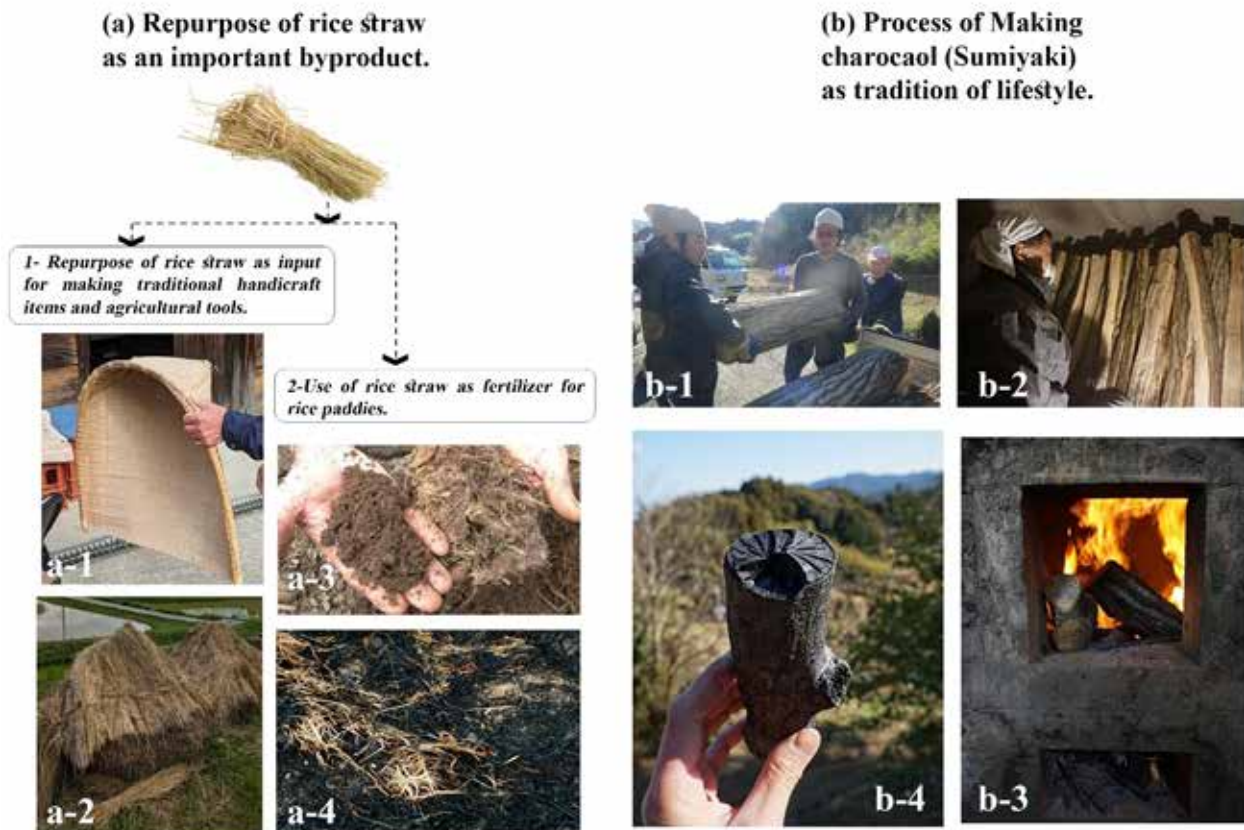


Fig. 2. Repurpose of rice straw and charcoal making as examples of community-based circular activities in Kamauma. a-1 basket for rice winnowing, a-2. Warabochi to protect rice from wind and rain 37), a-3, a-4. Repursue of rice straw as fertilizer for rice paddies, (b) process of making charcoal including collection, cutting, burning in the kiln and final product. Source: a. Authors, b. www.muji.net.

residents have long utilized these natural resources for daily needs. They craft bamboo baskets and rice-drying racks and produce bamboo charcoal for heating and other uses. Specifically, charcoal making illustrates a self-sufficient system rooted in the traditional Satoyama lifestyle and its sustainable use of local resources (Fig. 2-a).

“Here, we’ve always managed to live by making good use of what’s around us. Bamboo is really handy. We use it to make baskets and drying racks, and the leftover pieces we turn into charcoal to keep warm in winter. Well, we’ve tried to live using what’s around us” (K, male, 65 years old).

In contrast, interviews show that locals depend only on limited external inputs such as fertilizer, pesticides, and fuel for machinery. This aligns with circular economy principles of sufficiency, which emphasize not only recycling but also reducing overall resource use and “making do with less” (Bocken & Short, 2020; Godelnik, 2021).

• Kamanuma’s food circularity

The purpose of this section of the interview was to clarify how Kamanuma’s food system works. A common practice in Japanese villages is Chisan Chisho (local production for local consumption, LPLC), which refers to producing and consuming food locally (Hara et al., 2012), thereby fostering a resilient and sustainable food system based on local products. Based on interviews, local products such as rice (Koshihikari in Japanese) and vegetables are consumed by locals and, more importantly, are supplied to tourists. Moreover, locals exchange products such as vegetables, fish, rice, fruits, and other products with each other, indicating that they practice local bartering (Butsu Butsu Koukan). This demonstrates a local system that circulates food within the local community. Due to financial issues, farmers explained that they have had to adopt alternative means to supplement their income in addition to rice cultivation. They also produce processed goods (加工品) such as Japanese sake, jam, and Japanese sweets to offset the impact of low rice prices. Farmers produced such processed food by using natural resources from Satoyama and, more importantly, their own local rice.

“I have been running a café and restaurant here. For example, I use fish that can’t be sold and even bones to make a food called ‘Boso Bouillabaisse,’ and we make our own seasoning called ‘fish koji.’ We also use unripe mandarin oranges to make syrup, jams, and dressing. It’s all about finding new ways to make the most of what Satoyama gives us here” (E, female, 57 years old). To summarize this, findings of food circularity have illustrated different community-based activities such as bartering agricultural products and producing process goods. This created a local system where food and goods are circulated within the community for different purposes. Not only has it helped create a circular local food system with multifunctional productivity, but also strengthened self-reliance and self-sufficiency.

• Kamanuma’s tourism circularity

In terraced areas, circularity refers to the development of

sustainable and responsible tourism approaches that consider the emerging sharing economy, local foods, community economy, and tourism experience for stronger relationships between tourists and the local “heritage” communities (Council of Europe, 2005). Kamanuma is an appealing tourist destination due to its proximity to Tokyo and its beautiful landscapes, including forests and terraced rice fields. In terms of tourism activities, some farmers have been running farm stays (Nouhaku in Japanese) with their private homestays (Minpaku), allowing visitors to stay on the farm and participate in agricultural activities. Most importantly, local agricultural products such as rice, fish, and vegetables produced in Kamanuma are directly provided to tourists during their homestays. Not only does this create a Farm-To-Fork experience for tourists, but it also enhances the value of local agriculture as an integral part of Kamanuma’s circular tourism model and how food circularity and tourism are interconnected. This practice forms a localized food and tourism circular system, in which locally grown ingredients are consumed within the community, minimizing transportation and waste while reinforcing local economic cycles.

• Kamanuma’s knowledge and skills circularity

Local cultural and natural resources, community knowledge, and people’s experiences are crucial in contributing to sustainable development in rural areas. Locals are valuable sources of information, ideas, energy, enterprise, and knowledge transfer (Moseley Malcolm, 2003, 108). Farmers’ narratives revealed that Kamanuma once had a “circular lifestyle culture” (循環暮らしの文化), exemplified by a cooperative system called Yoningumi (Four-household group). In this system, farmers rotated labor for tasks such as rice planting, weeding, and harvesting. Members of the Yoningumi also supported the immigrant-led revitalization by sharing traditional knowledge and working together. They additionally held local meetings called Irokai (慰労会) to exchange advice, knowledge, and skills for community projects. These meetings also served as opportunities to share expertise on practices such as Kayabuki (roof rethatching, Fig. 1-e) before mechanization and depopulation reduced such exchanges. Overall, the findings indicate the existence of a local network that enabled residents with different specialties to collaborate on agricultural and community tasks, such as thatching, rice planting, and problem-solving, creating a system for circulating and transferring traditional knowledge both within the community and beyond.

• Kamanuma’s urban-rural circularity

Regarding urban-rural circularity, farmers commonly noted financial challenges, often saying, “You cannot make enough money by farming here.” Interviews revealed that government subsidies help reduce farmland abandonment, support agriculture’s multifunctional roles, and ensure farm survival. However, rice production is small-scale due to terraced land and is sold at low prices. Farmers also highlighted two main problems that emerged following depopulation.

Firstly, agricultural equipment and machinery account for a large part of farmers' budgets (around 10 million yen for a full set), limiting access for many. Interviews revealed that farmers manage this by engaging in group work and cooperation (共同作業), sharing machinery, mainly tractors, as a community-based strategy. This reflects a locally rooted sharing economy, where goods and services circulate within the community while social connections are strengthened (Pomponi & Moncaster, 2016; Szymańska, 2021). Most importantly, all farmers identified the lack of labor and successors as their most serious challenge, rooted in postwar urban–rural policies and long-term depopulation. This shortage is particularly severe in hilly and mountainous areas where machinery use is limited, making terraced farming in Kamanuma demanding, especially during summer, for an aging, depopulated community.

“Since the young people left for the cities, there are fewer hands to help, especially in these mountain areas where using machinery isn't easy. The amount of rice we can grow is also limited because the fields are small. There's hardly anyone left here, and little by little everything is shutting down, from managing the rice paddies to the communal work. We have to do all the farming ourselves. Some farmers even have jobs outside the fields, like working at the ward office, and then come back here at night to do farm work. We eventually couldn't manage the farming anymore and had to give it up” (D, male, 90 years old).

Interview findings revealed that several measures have been introduced to address the labor shortage through urban–rural exchange programs. For instance, various rice cultivation initiatives invite people from urban areas to Kamanuma to assist farmers with work in the terraced rice fields. Examples include the Kamogawa Satoyama Trust program, a collaboration between Muji Ryohin Keikaku and the Kamanuma community, and the Tanada Ownership System. These are volunteer farm works in which people from urban areas come to this village to participate in rice-making events, such as rice planting or rice harvest, to support agricultural work. Overall, the urban–rural circularity driver highlights major challenges such as the gap between agricultural income and expenses, limited access to farming machinery, and the community's strategy of sharing tractors to manage these constraints. However, the circularity and sustainability of such urban–rural exchanges require further clarification, especially in Japan's hilly and mountainous regions that are experiencing severe depopulation.

• Kamanuma's five drivers of circularity model

Returning to the research objective, a final model for Kamanuma will be presented to illustrate the role of each driver, their interactions, and their contribution to overall sustainability. Regarding natural resource circularity, traditional Tensui (rain-fed) rice farming represents a sustainable, circular method of water use. Since rice is the main agricultural product in Kamanuma, its by-product, rice

straw, has been reused for various purposes such as making agricultural tools and fertilizers. Charcoal production was also an important part of the Satoyama lifestyle, contributing to a self-sufficient local system. The natural resource circularity driver forms the foundation of this model, as rice cultivation in terraced fields and agriculture are central to the community, without this driver, other drivers would not function or hold meaning. The food produced through this driver is efficiently utilized within the community, either consumed directly by farmers or processed into local products such as sake and jams, forming a multifunctional and self-sustaining local food system. Moreover, the food driver is closely connected to the tourism driver through farm-to-fork experiences, where locally produced food is offered to visitors. The knowledge and skills driver demonstrates how the traditional cooperative system, Yoningumi, facilitated both the exchange of agricultural knowledge and the sharing of labor among residents. This mechanism not only preserved traditional techniques but also strengthened social ties and mutual support networks within the community. Collectively, this driver ensures that all available resources, human, natural, and social, are mobilized to maintain and enhance the community's overall sustainability. However, such cooperative farming of Yoningumi and social networks within the community faded after the mechanization and depopulation of the community.

Findings from the urban-rural circularity driver show that the community is still far from achieving sustainability and faces serious challenges such as labor shortages, low agricultural income, and limited access to machinery. With its population reduced to around 60, the community now depends heavily on urban-rural exchanges, which play a crucial role in sustaining other drivers. The urban–rural circularity driver plays a central and interconnected role in sustaining other circularity mechanisms in Kamanuma, serving as a key channel for various resources, especially human resources needed for agriculture, tourism, and local food production. The sustainability of other drivers and their resource circulation depends largely on the continuity and quality of these urban–rural exchanges. Therefore, maintaining sustainable urban–rural interactions is essential to support the natural resource driver as the heart of the system and other drivers, and to ensure the overall sustainability of the community (Fig. 3).

Conclusion

For Japanese rural communities to regain sustainability, they need to move toward a multidimensional, resource-based agricultural system through rural revitalization. This study shows that effective revitalization requires viewing urban and rural areas as an interconnected whole, linked through the continuous circulation of diverse resources, an essential condition for sustainable rural development (Li, 2012). In this context, rural areas can strengthen their place-based values and achieve development by

utilizing the landscape and resource capacities available through urban connections (Atashinbar, 2024). Among various resources, access to human resources emerges as a key factor in achieving long-term sustainability for rural communities such as Kamanuma. Volunteer programs and agricultural experience activities involving urban residents play a vital role in addressing labor shortages and sustaining agricultural and tourism-related activities. These interactions ensure a stable flow of human resources and enable other circular drivers to function effectively. Since rural landscapes are shaped through the continuous interaction between people and their environment, rural revitalization should begin with protecting existing local resources, particularly natural and agricultural resources, which form the core of rural communities. Building on this foundation, further environmental, social, and economic developments can contribute to long-term sustainable development. To achieve this, rural communities in hilly and mountainous areas need beautiful rural landscapes,

strong local resources, and community-based values; key prerequisites for revitalization and future development. Ultimately, by drawing on these resources and values, Kamanuma's sustainability can be secured through continuous urban–rural exchanges that support sustainable development. Most importantly, when applying and generalizing this model, careful management of diverse resources, especially human resources, and clarification of sustainable urban–rural exchange mechanisms are essential for restoring sustainability. Such exchanges are crucial not only for the revitalization of Kamanuma but also for other hilly and mountainous areas in Japan facing severe depopulation, where local resources alone are often insufficient to maintain agricultural landscapes and social functions.

Declaration of No Conflict of Interest

The authors declare that they have no conflict of interest in conducting this research.

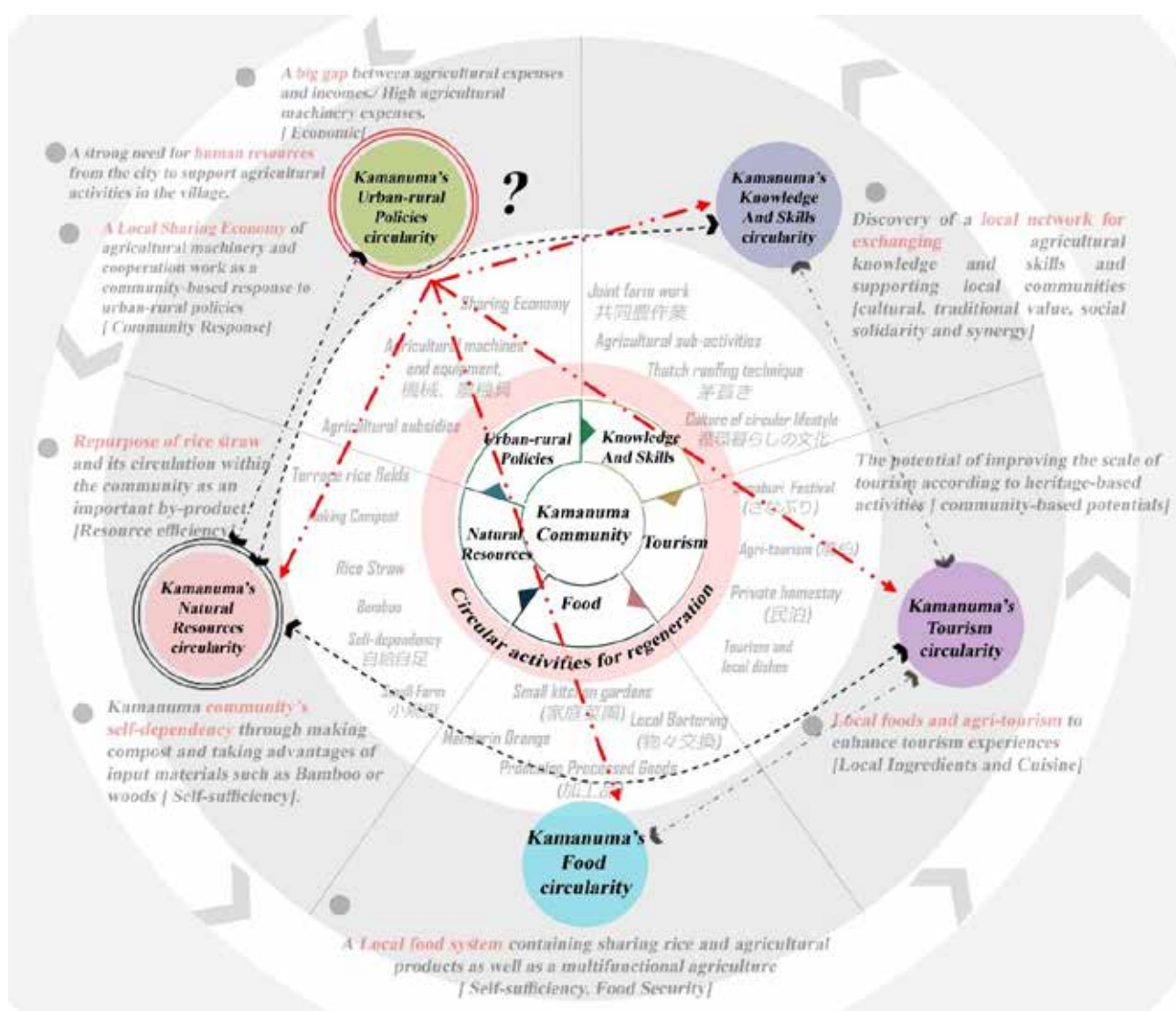


Fig. 3. Kamanuma's specific and contextual model of the five drivers of circularity, interactions, and their roles in regaining sustainability. Source: Authors.

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