

The Possibilities of Sustainable Landscape Observed through the Thatched Roofing in Yamaguni Region, Kyoto

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1. Background and Purpose of This Study

Up to the present day, Japan has continued to learn and improve, having experienced many crises such as environmental problems due to climate change, damage to natural resources, epidemics, and other difficulties throughout the years. During human activities, the mentality and culture of living in harmony with nature were nurtured, and even man-made buildings created as beautiful landscapes, blended in with the surrounding natural environment. Among these structures are the thatched roofs, which are seen not only in private houses but also in many architectural structures such as “Daijogu”, which is the sacred halls and used for the most important ceremony in Japan called “Daijosai” of the Imperial family, Ise Jingu Shrine, other shrines and temples. They become a part of the Japanese landscape culture, as mentioned in “Manyoshu” and “Hyakuninshu”, ancient Japanese poems. The thatched roofs have been rationally constructed, maintained, and developed within the context of available resources, lifestyles, communities, economic activities, and also in accordance with nature and ecosystem of the region. However, since the mid-Showa period¹, the changes in the social structure have led to the collapse of this common wisdom. One of the manifestations of this change was observed during the “Daijosai” in 2019, as thatched roofs were replaced with shingle roofs despite having a long tradition for more than 1,300 years. Local traditions and practices unique to each region are rapidly disappearing around the world due to the shortage of educators and documentations of these traditions that have been eventually lost in time. However, it is in these traditional practices that we can find wisdom and the accumulation of thousands of years of information regarding the important natural cycles, formation of local ecosystems, their maintenance and development, and essential facts for creating a sustainable society that coexists with nature.

This study focuses on the relationship between thatching and the local environment and aims to visualize and enumerate comprehensively the changes that have occurred in the region, and to examine the possibility of forming a sustainable local landscape that is associated in thatching.

2. Previous Study and Positioning of This Study

Previous studies on thatched roofing and the local environment are related to building systems and maintenance of thatched roof¹⁾²⁾³⁾¹⁴⁾, structure¹⁰⁾, technology⁴⁾, materials⁹⁾¹³⁾, living environment¹¹⁾, and landscape⁶⁾¹⁵⁾. Other related material focuses on ecology, geography, green geological local environments¹²⁾, ecosystem of thatch field⁷⁾, decomposing fungi on roofs⁸⁾, microbial and thermal environments in thatched roofs¹⁶⁾. There are few studies that take a comprehensive view of various fields such as climate, local resources, green space, ecosystems, landscape, logistics, lifestyle, and culture, and discuss the potential of thatching to shape the local environment in a modern society.

In addition, there have been no long-term research studies conducted through actual living in thatch-maintaining houses.

Essentially, the thatching process is an integral part of the local environment. In order to consider the construction of a sustainable society, research on the current situation and future possibilities is required based on the actual living conditions in a specific area. One of the roles of this study is to redefine thatching through visualizing the extensive characteristics of thatching.

3. Research Methods

3.1 Study Target Area

The Yamaguni and Kuroda areas (part of the former Yamagunisho) in the Keihoku area, Ukyo-ku, Kyoto City, are the target areas of this study. This area is located upstream from the Katsura River and is a stopover point on the Wakasa Kaido, a trade route to the central capital. The area is also famous for “Kitayamasugi” cedars, and has been supplying lumber, food, and other resources to the capital since the end of the Nara period (710-794). These resources were used to build the Heian-kyo capital, thereby supporting the culture of the capital and the nation. In building the capital, the Imperial Court dispatched officials such as Wake-no-Kiyomaro to the area, and a town based on the joubou system was built around the Yamaguni Shrine. Many important buildings, including “Daidairi” (the Imperial House), residences of nobles, Shinto shrines, and Buddhist temples, as well as the “Takamikura” (the Imperial Throne), the “Yuki-den” Hall and the “Suki-den” Hall, of the “Daijogu” were constructed of timber taken from the natural forests in the mountains of the upper Katsura River valley. The Yamaguni area is dotted with thatched roofs and has its own unique culture, such as natto (fermented soybean paste) rice cakes, making it a unique area among rural areas in Japan.

Table 1. Survey Contents and Duration

Period of Study	Contents
17/11/2019~17/1/2022	Field survey of the Yamaguni area, interviews with local residents, interviews with thatching-related people.
17/11/2019~31/12/2020	Kawarabayashi Residence (thatched roof) live-in site survey.
17/5/2021~17/1/2022	Inanami Residence (tinned roof) live-in site survey.

3.2 Method of Survey

The author had stayed for an extended period at a thatched roof house that operates a farmer's inn in the Yamaguni region and made interviews to Mr. Shigeri Kawarabayashi, the owner of the inn, and residents of the Yamaguni region about the thatched roof houses, natural environment, people's activities, and changes in their daily lives, to understand the overall lifestyle. The author had also stayed for an extended period at the Inanami House, a tinned roof house in the Yuge area, and investigated its transition and changes in the local environment. Regarding thatching, the author conducted a survey of thatching craftsmen and others based in the Miyama area of Nantan-city (Next to Keihoku. Former Kita-Kuwada County, together with the Keihoku area). In addition, the author had invited several bureaucrats from the

¹ Showa period: 1926 - 1989

Ministry of the Environment of Japan, who were seeking to create sustainable policies in Japan based on the axes of environment, economy, and society, to the Yamaguni area to discuss the possibility of creating a sustainable regional environment in this area.



Figure 1. (a) Raft floating around Taisho period (left), (b) Scenery of the Yamaguni area in 1933 (right) (Higae-cho, Yamaguni area) (Source: Mr. Kawarabayashi's collection)

4. Local landscape and thatching in the Yamaguni Area

4.1 Changes in the local landscape in the Yamaguni Area

Based on information obtained from interviews with local residents, Table 2 summarizes the changes in the local environment of the Yamaguni area from the early Showa period to the present. Those who know the area from the early Showa period say that it has become a desolate place now that nature has deteriorated, the number of people has decreased, and festive events have disappeared. Although visitors to the Yamaguni area say that it is still beautiful, there is a divergence in the perception of the area between the residents and visitors. From the lifestyle in the past as to be circulation of local resources, supplying products such as lumber and food to the capital, providing food, clothing and houses by themselves in their own community, the economy shifted after the WW2, most of necessities for their life became to be supplied by currency and “Tengori” (community work related to rethatching and farming) was eventually replaced to be works paid by currency. And thatched roofs were gradually become to tinned roofs. In the past, the local resources obtained from the forests were the common property of the district, and the local residents had been self-governed even building schools and community centers. However, today, the value of the local resources has decreased, lifestyles have changed, the economic base of the district has shrunk, and animal damage has begun to increase due to the lack of maintenance to care for the mountains. The economy of the entire region, which had been supported by the forestry industry, has also declined, and the population of the Keihoku region, which once numbered 10,000, has been decreasing at a rate of 100 people per year, and now stands at approximately 4,500. The local environment in the Yamaguni region has changed drastically, with a decline in the number of shops and other infrastructure that used to be present.

Table 2. Changes in the local environment in the Yamaguni region

Period	Forest	Village	River	Thatched Roof
Early Showa Period (from about 1926 to 1945)	Sources of energy, fertilizer, and food were obtained from the forest. There was diversity in the mountains with mixed forest.	Fuel for cooking and bathing was firewood from the mountains behind one's house. Local life that depend on the resources of the backwoods on a daily basis and care for them.	Lumber, resources, and food were transported to downtown Kyoto by rafts.	Half of the houses were thatched with thatch and another half were thatched with cedar barks (materials are obtained from around the house)
Mid-Showa Period (from about 1945 to 1965)	Nearly bald mountain due to demand for lumber during and	Fuel becomes propane gas and no longer needs to take firewood from	Transportation of lumber, resources, food was started by	Residents gradually had become less and less likely to

	after the war. Expanded afforestation and the “Kitayamasugi” boom led to an increase in planted cedar and cypress forests. The diversity of tree species becomes smaller. Matsutake mushrooms were still plentiful.	the mountains. Thatch will be replaced by artificial forests of cedar and cypress. Automobiles become the means of transportation. Population outflow to cities begins. Start of use of pesticides.	trucks. Frequent river flooding due to reduced water retention in the mountains. Many fireflies and eels in the small river.	replace their own roofs and pay contractors to do it for them. “Tengori” began to decline.
Late Showa Period (from about 1965 to 1989)	Matsutake mushrooms were still plentiful.	Progressive shift to nuclear families. Thatch field shrinking.	Many fireflies and eels in the small river.	Wealthier houses started to cover the roof with tin and the “Tengori” declined.
From the Heisei Era to the present (from 1989 to 2022)	Almost no matsutake mushrooms harvested. Reduction in the activities of property management associations. Artificial cedar forests fallen due to typhoons. Untouched forests became larger.	Thatch fields almost disappeared except for riverbeds. Damage of rice and vegetable fields started by deer, boars, monkeys, and other animals. Fences in these fields against it destroyed local landscape. Shrinkage of stores and other infrastructure for daily life. Decrease in population due to loss of employment.	Decrease in the variety and quantity of fish. Water quality deteriorated due to domestic wastewater. Eels were disappeared. Fireflies decreased.	Traditional way of “Tengori” completely disappeared. Instead of it, new relationship between local, immigrants, and visitors to help each other has eventually started born.

4.2 Transition of thatching in the Yamaguni area

(1) **Thatched Roof** Around the early Showa period, half of private houses in the Yamaguni region were thatched roofs with thatch and another half houses were with cedar barks. Today, most thatched roofs with thatch have been replaced by tin roofs (thatched roofs covered with tin, copper sheet, stainless steel sheet, or galvalume steel sheet), and cedar bark roofs have been replaced by tile roofs. These roofs still make up the distinctive local landscape. From around the mid-Showa period, sheet metal contractors and the government began to recommend the use of tin roofs, which were considered a safe roofing method, and houses that could financially afford it began to have tin roofs. The reasons for this shift were due to the aesthetic appeal of tin roofs, convenience of maintenance as there was no need to rethatch the roofs, and also for safety because they were not a fire hazard. On the other hand, those who could not afford it could continue to maintain thatched roofs because they could maintain their roofs with lower cost by preparing and supporting works by themselves: harvesting thatch, supporting thatcher's work. Currently, there are 10 private houses, one temple, and one hut in the Yamaguni area that retain their thatch, which makes a total of 12 buildings. There are 3 private houses and huts with thatched roofs that have collapsed, and 124 with tin roofs. In the Yamaguni area, the number of tin roofs began to increase around 1970, which means that over the past 50 years, thatched roofs have been replaced by tin roofs at a rate of about 5 cases per 2 years. In

recent years, according to the results of a survey conducted by Mr. Kawarabayashi in the Yamaguni area in 2007⁵⁾, there were a total of 19 thatched roofs in the area at that time, and the number of thatched to tin roofs has been changing at a rate of one per two years, or at an unsustainable rate. If the pace of recent years continues, thatched roofs in the Yamaguni area may disappear by 2045, 24 years from now.

(2) **Thatch Field “Kavaba” and Thatch “Kava”** If we define a thatch field as a land where thatch, which is used as roofing material, grows over 80% of the area per unit area, there are a total of 45158.7 m² of thatch fields in the Yamaguni area, most of which are riverbeds, and the quality of the thatch varies from place to place. In the past, most of the thatch fields were located at the foot of the mountains behind houses, which were convenient for carrying it out after harvesting, and served as a kind of buffer zone separating the village for human and the deep mountains for animals. Those thatch fields are now mainly artificial forests of cedar and cypress trees. In the past, the area was self-sufficient in thatch, but nowadays thatch is often left to contractors’ supply. There is currently no thatcher in the Yamaguni region and thatching here is often by thatchers in the Miyama region. But even the Miyama region, self-sufficient of thatch is no longer enough and most of materials are Japanese pampas grass from Aso or Ehime and from Miyama is only 10% for their supply quantity.

(3) **Thatcher** Until around the 2000s, there were a few thatchers who were from near the Keihoku area and were active in the Yamaguni area. Currently, thatched roofs in the Yamaguni area are maintained by “Miyama Kayabuki Co., Ltd.,” “Nisio Supplies Co., Ltd.,” and “Kayabukibuna Co., Ltd.” in the Miyama area, and “Yamashiro Kayabuki Co., Ltd.” from southern Kyoto.

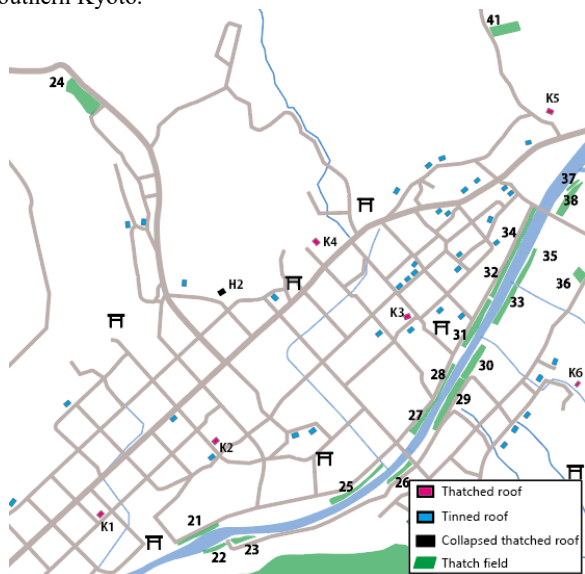


Figure 2. Distribution map of thatched roofs, tin roofs, and thatch fields in the Yamaguni area (example of the second area in a total of eight survey area)

5. Houses that maintain thatched roofs and the local environment

5.1 Kawarabayashi Family History and Kawarabayashi Residence

Mr. Shigeri Kawarabayashi is the 20th generation of the Kawarabayashi family which has existed since the Muromachi period (1333-1573). The Kawarabayashi family was originally a samurai family, and during the Edo period, they held the title of village headman and had a license to operate a rafting business. Today, Mr. Kawarabayashi works as a paper framer in his own

right and runs a farmhouse guest house with his daughter, welcoming guests from Japan and abroad. The house is built by Japanese traditional architectural structure with stone foundation, cypress, and pine structure. The roof is thatched with thatch, and the attached lower part of the roof was originally thatched with cedar barks but are now tiled. The wooden structures on the top of the roof as ornament and weight for thatched top part called “Yukiwari” and “Chigi” were made by Mr. Kawarabayashi himself from chestnut trees cut in the surrounding mountains. The attic structure shows signs of having been converted from another house. According to the survey by administration, it is estimated to be over 220 years old and is the only thatched roof house in the Keihoku area with nine “Chigi”, except for Joshokoji Temple in the same Yamaguni area, and is the largest private house in the area. Thatched roofs in this area are called “Kitayama-style” and are generally “Tsumairi” which has an entrance on the gabled side, but the Kawarabayashi Residence is “Hirairi” which has an entrance on the parallel side to the roof ridge and it has a “Nagayamon” (long house gate). Comparing the late Edo period plan (Figure 4) with the current plan, the following changes can be confirmed.

- The earthen floor became a modern kitchen, living room, and two Japanese-style rooms.
- The seven “Okudo-san” (cooking stoves) in the earthen floor area were reduced to only one “Sanpo-san” (the largest cooking stove) and modern kitchen systems were installed.
- The sunken hearth room was divided into two.
- The toilets, which were in a separate building outside, were relocated inside the house.
- A bathroom, washroom, and study were added on the east side of the house.

The Katsura River flows in a curve around the Kawarabayashi Residence, and behind it are mountains, man-made forests, and forests of broad-leaved trees. The rice paddies in front of the river, together with the Kawarabayashi Residence, create a typical rural landscape, a manifestation of the landscape culture that Mr. Kawarabayashi has maintained while adapting it to modern lifestyle and this notable way of life is covered by various media outlets.



Figure 3. (a) The south side of Kawarabayashi Residence (left), (b) The surrounding environment of the north side of Kawarabayashi Residence (right) (Ono Town, Yamaguni, Photo by Author, April 2020)

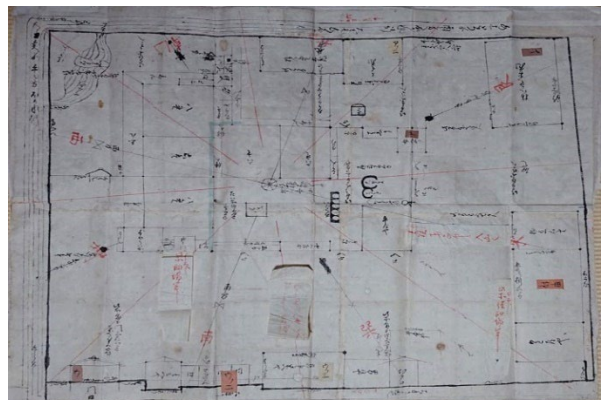


Figure 4. Plan of late Edo period of Kawarabayashi Residence (Mr. Kawarabayashi's collection)

5.2 Cyclicity and rationality of the current lifestyle of the Kawarabayashi family

The Kawarabayashi family lives a near-self-sufficient lifestyle, not only by harvesting thatch for their own roof, but also by cultivating fields, raising chickens, doing simple renovation works, and making furniture. Table 3 summarizes the rationality and irrationality of the living conditions observed during author's stay at the Kawarabayashi family from November 17, 2019, to December 31, 2020. As observed, the Kawarabayashi family has realized a sustainable lifestyle by continuing traditional way of life, reducing waste, and taking the time and effort to maintain their house and furniture, while living a modern lifestyle with electricity, gas, and running water. In addition, compared to modern housing and lifestyles, they can live sustainably in the event of disasters due to near-self-sufficient lifestyle. In recent years, they have been operating a farmhouse guest house, where guests can experience harvesting thatch, dressing chickens, and picking vegetables and fruits, as well as serving as providing of education and information.



Figure 5. (a) The sunken hearth “Irori” for cooking and floor heating (left), (b) Firewood made from old “Chigi” taken down from previous rethatching (right) (Kawarabayashi Residence, photo by the author, July 2020)

Table 3. Rationality and Irrationality of the Kawarabayashi Family

	Rationality	Irrationality
Thatch harvesting ~ Rethatching	<ul style="list-style-type: none"> Save money on materials. Can be done while having fun with others. Can dry thatch in the rice field. 	<ul style="list-style-type: none"> Manpower and time consuming. One-person operation is hard work. The thatch harvesting is affected by the weather and the calendar (major and minor crimes).
Living environment	<ul style="list-style-type: none"> Summer: cool and well-ventilated. Winter: Thatch itself has high thermal insulation performance, and it is warm if the hearth or okudo-san is kept burning all year round. No condensation, no fear of sick building syndrome. Health can be maintained in the same microbiological environment as in nature without pathogenic bacteria¹⁸). 	<ul style="list-style-type: none"> Summer: Mold tends to form in rooms due to the structure on the ground and high humidity climate in the region. Winter: Cold due to drafts because of low insulation performance of the floor and wall. Even when the hearth is heated, the underfloor is cold (Mr. Kawarabayashi remodeled it to use as underfloor heating).
Sunken hearth	<ul style="list-style-type: none"> Can keep warm and eat around a fire. The smoke from the hearth makes thatched roofs last longer and purify the air and interior. 	<ul style="list-style-type: none"> It takes about 30 minutes to build a fire. Smoke may be heavy depending on the type of wood and how dry it is.
Firewood	<ul style="list-style-type: none"> From nearby mountain (less CO₂ emission to get energy). Fire can be kept burning for a long time after building. The wood from rethatching can be used as firewood. 	<ul style="list-style-type: none"> Time-consuming to procure and dry.
Kitchen	<ul style="list-style-type: none"> High fire power. A door separates the living room from the kitchen, preventing smoke from entering the living room. 	<ul style="list-style-type: none"> Large amount of smoke when the fire is built.
Rice field	<ul style="list-style-type: none"> Roofing materials, thatch, and wood, become as fertilizer. 	<ul style="list-style-type: none"> Need a place to store thatch compost and old wood.
Vegetable fields	<ul style="list-style-type: none"> Roofing materials and chicken manure become fertilizer. 	<ul style="list-style-type: none"> Need a place to store thatch compost and old wood.

Chicken raising	<ul style="list-style-type: none"> Eggs and meat are obtained from cooking scraps and leftovers. Free range eggs in the garden keep them healthy and produce good tasting eggs. Saves time and effort in weeding. 	<ul style="list-style-type: none"> It takes time and effort to raise them (about 6 months from hatching to egg-laying). Requires a place and facilities for breeding.
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5.3 Maintaining the thatching of the Kawarabayashi family

The Kawarabayashi family harvests thatch every year from November to December. In the past, harvesting thatch was done at a thatch field near the house, but about five years ago, they began to rent thatch field No. 24 (about 1,850 m²), shown in Figure 2, which was a rice field. In recent years, guests staying at the farmhouse guest house, university faculty and students in Kyoto city, and parents and children have been participating in the thatch harvesting as events. Techniques of thatching and harvesting thatch was inscribed as a UNESCO Intangible Cultural Heritage in 2020. However, harvesting thatch as roofing material requires a certain level of skill, and thatch harvested by novices may not be used as roofing material. Calculating the productivity of thatching, Mr. Kawarabayashi's productivity is about six times that of a novice. The roof of Kawarabayashi Residence was replaced in October 2019, after about 38 years, by “Miyama Kayabuki Co., Ltd.” for the entire north face and the upper part of the south face, with friends and guests from the neighborhood joining in to help. All the thatch needed for rethatching was provided by Mr. Kawarabayashi. In addition, 1/3 of the cost of rethatching was subsidized by administration support through its own subsidy program, according to Mr. Kawarabayashi, was a major factor in making the rethatching this time possible.

Table 4. Cycle of rethatching in Kawarabayashi Residence

Rethatching area	The time before last (year)	Previous (year/month)	Next Schedule (year)	Cycle Year (approx.)
All surfaces of the north face	1981	Oct/2019	2054	38 Years
Top surface of south face	1981	Oct/2019	2054	38 Years
East and west faces	1999	-	2031	32 Years
Lower surface of south face	1999	2007	2031	32 Years
“Yukiwari” (chestnut wood)	1981	Oct/2019	2057	38 Years
“Chigi” (chestnut wood)	1941	Oct/2019	2097	78 Years

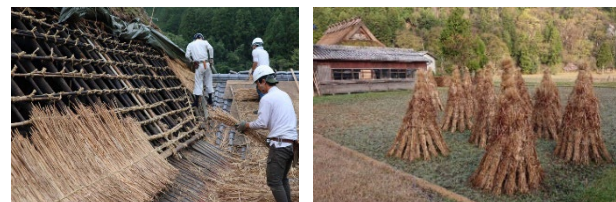


Figure 6. (a) Scene of rethatching (left) (Mr. Kawarabayashi's collection), (b) Scene of drying thatch until next spring (right) (photo by the author, November 2020).

5.4 Activities of the Kawarabayashi family and social evaluation

He has been interviewed by TV (such as NHK WORLD, NHK, KBS), newspapers (such as Asahi, Yomiuri, Kyoto

Shimbun), and other media for his effort of making beautiful and sustainable local landscape with near-self-sufficient lifestyle what used to be usual until mid-Showa period and activities with the non-profit organization "Furusato Keihoku Hokosugi Juku" and other local activities. Local residents are no strangers to Mr. Kawarabayashi in Keihoku as a person who cherishes local history and culture.

5.5 The Inanami family and the transition to a tinned roof

The Inanami family was a prominent family in the Yuge area since Muromachi period (1336-1573). In the Meiji period (1868-1912), Mr. Masutaro Inanami established a sericultural business and served as the mayor of Yuge Village and the chairperson of the Kita-Kuwata County Council. In addition to the development of the local economy and job creation in the region, he had contributed to build an elementary school and local community center by providing land and funds, was trusted by local residents and also awarded the Medal from Japanese Government and the Emperor. The research has shown that wealthier houses had changed to tinned roofs from thatched roofs at an earlier stage, but the Inanami family had the financial means and the head of the family at the time was fond of new things, so they covered the house with tin around 1970 and changed the earthen floor, "okudo-san", and cow shed inside the house to the modern layout.

Comparing the lifestyles of the Kawarabayashi and Inanami families in Table 5 and evaluating them in terms of local completeness of material circulation related to architecture, food, and energy, the Kawarabayashi family has a higher degree of sustainability. Considering that the lifestyle of the Kawarabayashi family was common in the past, many families shifted to a lifestyle like that of the Inanami family around the mid-Showa period, the degree of circulation and sustainability within the region has decreased dramatically. Since the lifestyle of the Kawarabayashi family can be found to have been established in the material circulation of local resources even today, it can be inferred that the way the area used to be, can be used to suggest the formation of a sustainable landscape what is comprehensive environment by accumulation of human lifestyle and natural environment that can be applied even today.

Table 5. Comparison of the current level of sustainability, cyclicality for environment and self-sufficiency, of the two houses

	Kawarabayashi family (thatched roof)	Sustainability	Inanami family (tinned roof)	Sustainability
Roofing	Thatch is locally produced and unloaded thatch is used as fertilizer for the fields.	○	Periodic coating of tin is required.	×
House maintenance	What they can do it without spending money, they do it themselves.	○	Pay the price and leave it to the contractors.	×
Food	Rice, vegetables, and chickens are largely self-sufficient. Others are purchased.	○	In the past, vegetables and chickens were self-sufficient. Now everything is purchased.	×
Water	Tap water and well water.	△	Tap water only.	×
Energy	Summer: only a fan when it is hot. Winter: oil heater, kotatsu with charcoal briquettes, and sunken hearth. The ashes from the hearth are used as fertilizer for the fields. Living with local resources and fossil fuels.	△	Summer: It is too hot with only a fan. Winter: oil heaters, kotatsu, electric heaters. Living mainly rely on fossil fuels.	×



Figure 7. (a) Inanami Residence (left) (b) The current appearance of the elementary school built by Mr. Masutaro Inanami (right) (Yuge area, photo by the author in 2021)

6. Conclusion

As a result of this study, it became clear that the series of processes that "thatching" possesses are not only the architecture of the thatched roof alone, but also strengthen the relationship between the climate and culture specific to the region, natural environment, people's activities, lifestyles, and material circulation within the region and economic activities outside the region and constitute a comprehensive indicator of a sustainable local landscape, including culture and landscape.

Thatched roofs have the potential to continue to exist in different forms, just as thatched roofs once survived as tin roofs. In addition, if we focus on the comprehensive viewpoint of "thatching" revealed by this study, it could paradoxically become one of the driving forces for creating a sustainable local landscape by creating new thatching values that solve the issues required by today's society in Japan and in the world.

The Cabinet Office approved the Fifth Basic Plan for the Environment in April 2018, and the Ministry of the Environment proposed a "Regional Circular and Ecological Sphere" based on cooperation among autonomous regions. This is a policy to simultaneously solve various regional issues such as climate change, population decline and employment, maintenance of the natural environment, and industrial development, as well as a concept to maximize the vitality of Japan's regions, including farming, mountainous, and fishing villages and cities. The most important thing in creating a sustainable local landscape in the Yamaguni regions of Japan, while taking such policies into consideration, is the perspective of utilizing the potential of "thatching" in the creation of a comprehensive regional environment in modern society, as this study has revealed. At a time when climate change, environmental problems, and the diseases such as COVID-19 are changing lifestyles and people's sense of values, further research is demanded to apply the true value of "thatching" as system to design and create sustainable environment to the modern society including Japan and the world.

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