Journal of Rural Studies 68 (2019) 46–53

Contents lists available at ScienceDirect

Journal of Rural Studies

journal homepage: www.elsevier.com/locate/jrurstud

Impact of Geographical Indication schemes on traditional knowledge in changing agricultural landscapes: An empirical analysis from Japan

Ai Tashiro[b], Yuta Uchiyama[a,b], Ryo Kohsaka[a,b,*]

[a] Graduate School of Environmental Studies, Nagoya University, Japan
[b] Graduate School of Environmental Studies, Tohoku University, Japan

ARTICLE INFO

Keywords:
Geographical indication
Traditional ecological knowledge
Agricultural landscape
Rural development
Japan

ABSTRACT

A Geographical Indication (GI) is expected to facilitate agri-environmental management in agricultural landscapes. Currently, local products from small-scale farms and national branded products with a relatively large scale of production are being registered using GI schemes. Considering the relationships among GI products, their agricultural landscapes, and traditional ecological knowledge (TEK), as a GI case study, we examined small GI farms in Odate City, Akita Prefecture, Japan, which produce edible plants called *Tonburi*.

This research explored the complex cause-effect relationship between TEK and landscapes and found that the TEK of *Tonburi* production influenced biological diversity and vice versa. The TEK and skills of small farmers were confined to the family members of each farmer and were not shared at the community level until GI registration. However, the farmers shared their TEK of sustainable agricultural landscape management through the process of GI registration. Through negotiation between local agricultural cooperatives and farmers, TEK was provided as a form of cultural capital and shared with new producers after GI registration.

We concluded that enclosed TEK negatively affects production maintenance and landscape management in the long term. However, the GI registration process contributes to the sharing of TEK as a form of cultural capital among *Tonburi* farmers.

1. Introduction

Products under the framework of Geographical Indications (GIs) closely interact, both physically and culturally, within a specifically defined geographic location, as these are mandatory conditions for registration. In other words, GI products are associated with socio-ecological systems and landscapes that are closely dependent on the socio-institutional and regional GI context of the specific rural locality. GIs are frequently regarded as a legal instrument to protect or at least foster traditional methods and commensurate lifestyles (Broude, 2005). Thus, GIs are inherited in agricultural landscapes or are frequently embedded in the local landscape.

This study has three goals in terms of contributing to the agri-food literature in rural studies: (1) to examine an Asian case of recent adaptation of GI relative to the European experience, (2) to identify the role of GI in preserving both traditional ecological knowledge (TEK) and agri-environmental landscapes, focusing on the production of edible plants called *Tonburi* in Japan, and (3) to develop an innovative method for studying the historical evolution of cultural (TEK) and natural capital (landscape) with long-term data.

GIs have been studied from various perspectives of local knowledge of the environment or place-based concepts, including producer networks, product reputation, and traceability, but few of these studies have concentrated on the physical aspects of the landscape. The physical aspects include local varieties or breeds, soil conditions, and seasonal patterns of land use in agricultural landscapes. Despite such apparent interlinkages with GIs, physical agricultural landscapes have not received adequate conceptual attention in the discussion of GIs. As for European or Asian cases (Bennett et al., 2018; Garcia et al., 2007; Haines-Young et al., 2006), ecology and landscapes have received less attention in the GI discussion than communities and products. A change in local culture and knowledge of production would influence agricultural landscapes. GI registration would facilitate the sharing of TEK and the hidden techniques and skills of production with new producers. TEK and technical practices also have an influence on biological diversity (Bowen and Zapata, 2009). Thus, an understanding of GIs as a product along with the interaction of natural and human factors is necessary (e.g., the 1958 Lisbon Agreement).

Currently, residents, local communities, environmental groups, and local governments around the world are implementing and promoting

* Corresponding author. D2-1(510), Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan.
E-mail address: kohsaka@hotmail.com (R. Kohsaka).

https://doi.org/10.1016/j.jrurstud.2019.03.014
Received 5 June 2018; Received in revised form 11 March 2019; Accepted 15 March 2019

actions to steward the agricultural environment (Davy et al., 2017). The term agri-environmental scheme (AES) has been used to refer to different measures such as creating protected areas, replanting trees, limiting harvests, reducing harmful activities or pollution, and restoring degraded areas. It is applied to describe rigid environmental conservation actions, active restoration activities, and sustainable use and management of resources. Considering AES practices, this study focused on the central role of local people in environmental stewardship and the sustainable production of local products with GIs.

Due to the place-based character of GIs, the impression of improved food security is propagated along with the image of local agricultural production instead of mass production. Consumers demand products with certifiable provenance and unique origins connected to the local landscapes (Blakeney, 2014; Bowen, 2010). In this sense, GIs have become embedded in ecological landscapes in resistance to the dominating global dynamics of agri-food markets (Bowen and Zapata, 2009; Goodman, 2004).

Regarding land use, agricultural intensification or land-use zoning in a country triggers compensatory changes in trade flows, and thus, can indirectly affect the landscape. The most important form of land conversion is an expansion of crop and pastoral land in natural ecosystems (Bowen, 2010; Lambin and Meyfroidt, 2011). The conserved land links farmers' histories, social organizations, activities, and agricultural practices. The TEK and technical practices influence and sustain biological diversity. GI schemes that prioritize land can be designed to protect local resources such as soil type, native plant species, and microclimate. Such unique lands are essential to the specificity of the product and shape the agricultural landscape. In this context, GI schemes are instrumental to the advancement of the useful concept of the agricultural landscape in forming both cultural and physical landscapes (Stroman and Kreuter, 2016). Given the significant development of GIs in agricultural landscapes, academic attention has been devoted to analyzing the behaviors of farmers in the GI process, including their internal application periods (Tashiro et al., 2018). The small-scale GI farm's practical strategy is essential to the maintenance of the agricultural landscape (Bowen and Zapata, 2009; Tregear et al., 2016).

In practice, AES was first introduced in the United Kingdom in 1986 by land managers as a knowledge base to respond to and understand the environmental status and trends (Boatman et al., 2008; Kishioka et al., 2017). To provide further information on the more physical aspects of an agricultural landscape under a GI scheme, we demonstrate that the framework of AES is useful for elucidating the actual status and trends of GI schemes. Along with designated geographical areas, AES facilitates spatial analysis of GIs. Furthermore, studies of GIs in Asia, including Japan, where GI schemes are new, are relatively limited.

Given these conditions, the objective of this study is to determine how effectively the GI registration process contributed to opening an enclosed TEK. TEK incorporates a functional linkage between cultural capital and natural capital to be shared among *Tonburi* farmers. In contrast to most existing TEK contexts, we explicitly posed and attempted to answer the following question: What were the interactions associated with place-specific landscape and agri-environmental management? Placing an emphasis on the role of spatiality and existing diversity of rural areas, we explore the landscape focus as well as the human-environmental interaction. We additionally clarify the local innovation pathway in the cause-effect relationship between cultural and natural capital (Belmin et al., 2017; Bennett et al., 2018).

2. Agri-environmental schemes and the challenges of a small GI farm

Scholars have explored the theoretical associations between GIs, terroir, and local environmental and cultural resources (Marchenay, 2006; Marie-Vivien et al., 2015). However, few studies have examined the relationship between GI schemes and landscapes in an empirical manner. In the first comprehensive study of the environmental effects of GI protection, Riccheri et al. (2006) compared eight GI systems and found that GIs had a positive influence on biodiversity conservation and maintenance of cultural landscapes. They also found that intensification processes such as farm specialization, mechanization, and increased reliance on inputs had visible negative environmental impacts under GI protection.

Nature conservation is a major landscape management activity in the European Union and accounts for the highest conservation expenditure in Europe (Batáry et al., 2015). In recent years, government directives have provided incentives and instructions that consider landscape elements (Boatman et al., 2008; Torre et al., 2012). AES was a part of a government system that was designed partly to address the conservation of species and ecosystems in Europe and depended on agricultural management. The most significant AES was a countryside stewardship scheme established in 1991. UK farmers converted their agricultural practices to organic production and achieved a variety of positive environmental outcomes. Since then, AES has led to an expanding landscape-scale perspective (Prager et al., 2012; Morris et al., 2000; Zasada et al., 2017). They have also evolved to achieve effectiveness, and similar expectations exist as effects for registration with the- GI schemes. Farmers may follow such directives because they are increasingly dependent on subsidies. Alternatively, under the framework of AES, farmers regard themselves as custodians of the countryside and want to enhance it for the benefit of biodiversity, agricultural communities, and visitors (Tsilimigkas and Kizos, 2014). At the conceptual level, AES is not only a management approach but also an ethical system that emphasizes responsibility, collaboration, participation, and communication in planning and management of landscapes (Zhu et al., 2018).

In this context, researchers have focused on the capacity to deliver landscape services that contribute to rural viability. Numerous models and frameworks have also been developed to improve the integration of mechanisms and relationships between policies, landscapes, and socioeconomic values. Although GI schemes related to the landscape have been discussed for the geographical areas in southern Europe and Latin America (Agostino and Trivieri, 2014; Guedes and Silva, 2014), GI schemes in Japan and other Asian contexts have been largely overlooked. It is partially due to their relatively short history and an impression that the schemes in Asia are not directly associated with the conservation of natural resource, although researchers have discussed the sustainable use of local resources under a GI scheme (Uchiyama et al., 2017a).

In Japan, in particular, GI farms frequently intend to revive rural development through GI strategies, although most of them are small-scale farms. The priority of environmental quality management is not high in the strategy of these farms, and the effects of GI products on environmental management are rarely included explicitly in the explanation of individual GI products. To develop a framework for a GI scheme that contributes to ecological management as well as rural development, the EU and Latin American cases must be considered. These suggest that GI products can be produced with a more environmentally benign approach, apart from standard approaches to industrial and agricultural production. Furthermore, GI products contribute to the conservation and maintenance of distinctive cultural landscapes (Bennett et al., 2018; Lau, 2013; Locatelli et al., 2014).

Therefore, the GI cases from Japan provide us with a unique opportunity to explore and examine the relationships between GI schemes and AES outside of the EU contexts. Small farms in the Japanese countryside seek to appropriate management of natural resources and the maintenance of biodiversity and cultural landscapes (Bieling and Plieninger, 2017).

To contribute to the development of the theory of the relationships between AES and GI and elaborate on the methods of empirical analysis of these relationships, this study analyzed the case of a small GI Kochia farm to evaluate the effects of production associated with multifunctional landscapes and ecological sustainability in the local

community of Odate City, Akita Prefecture, Japan.

3. Methodology

3.1. Research methods

This research aims to identify the impacts of GI on changing agricultural landscapes and TEK as the cultural capital of small GI farms. For this purpose, it adopts the framework and approach of suitability modeling, which is broadened by linking the idea of TEK (cultural capital) and landscape (natural capital). The approach is illustrated through a case study of a small GI farm that produces *Tonburi*, the seeds of Kochia, in Odate City, Akita Prefecture. The presence of processes to maintain connections to place, TEK, practices, and artifacts of the farm were analyzed.

A review of the existing literature and a survey and analysis of the case were also conducted. During the survey, a representative of the Japan Agricultural Cooperative (JA) of *Akita Kita*, which is the main player in the supply chain of *Tonburi*, was interviewed about the history of the production area and the role of JA in this process.

The local environmental stewardship framework proposed by Bennett et al. (2018) and the analytical framework of a transition theory on GI (Belmin et al., 2017) were applied to develop a methodological framework to identify the impacts of GI on landscapes and TEK. The concept of Haines-Young et al. (2006) was also referenced in the model of agricultural landscapes on natural capital. This concept highlights the spatial variability of flows of ecosystem services, land use, management costs, and economic benefits, based on the influence of consumer distribution in rural areas.

Zasada et al. (2017a) argued that the attractiveness of a biodiverse landscape could positively influence conservation activities. Pfeifer et al. (2009) examined the role of site-specific natural conditions and their influence on farmers' decisions to conduct environmental management.

These earlier approaches only partially resolve the problems we face when dealing with natural and cultural capital. In contrast, we examined how to overcome the limitations of current approaches. Therefore, this study analyzed a largely unexplored cause-effect relationship between cultural capital (TEK) and natural capital (landscapes) using the results of interviews with JA *Akita Kita* and a representative of Tonburi farmers (Table 1).

By using the spatial aspects of agricultural landscapes associated with TEK of the GI farms, we aimed to provide a framework to better address the management issues that arise in the context of a sustainable, multifunctional GI agricultural landscape.

3.2. Research site: past and present context of agricultural landscape

Odate City in Akita Prefecture (140°19′–140°44′ E, 40°02′–40°29′ N) is a major Kochia-growing region in northwestern Japan (Fig. 1). Processed seeds of Kochia, "*Tonburi*," were registered as the 32nd GI product of Japan on May 26, 2017. Kochia (*Kochia scoparia (L.)*), is a round shaped, annual grass that bears *Tonburi*. The agricultural landscape comprises of *Tonburi* fields, and farming has been conducted in an environment surrounded by forests (Fig. 2). *Tonburi* is inherent in the agricultural landscape, and the agricultural landscape has fostered the creation of *Tonburi* fields. The loss of *Tonburi* fields from Odate's agricultural landscape would mean the loss of the landscape's uniqueness and its related TEK. Agricultural landscapes in Odate, including *Tonburi* fields, can be seen in the *Ohu* and *Dewa* mountains. The city is also richly blessed with spring water. The Yoneshiro river flows along the lowlands to a mid-to small-size river basin named as the Odate Basin. Mountains surround Odate, blocking the city from strong winds and maintaining its unique climatic characteristics. *Tonburi* fields harmonize with the flourishing landscape. According to Green report (2017), seasonal changes and mosaic agricultural lands with associated social and ecological systems evoke nostalgic feelings for residents and visitors. The scenery changes depending on the time, climate, and season. There is nothing more than a sylvan scene, but it is attractive for visitors and residents.

In the ecological landscape, local cultivation sites are limited to the central districts of Odate. However, the Tokko district, a rural part of the city administrative area in the mountains, has large-scale *Tonburi* fields that are up to 50 ha in area. The district is on a plateau surrounded by a cedar forest. In general, the well-drained land is not suitable for paddy-rice cultivation but appropriate for *Tonburi* production. First, *Tonburi* is cropped by hand, so the drained land is suitable for harvest activities. If it was muddy, it would not be useful for cultivation. Second, a typhoon can potentially harm *Tonburi* farms with strong winds tearing down the seeds. However, owing to the cedar forests, there is little damage in the area due to typhoon. Thus, the agricultural landscape in the district is well-suited for *Tonburi* production.

Tonburi's characteristic is unique and different from other GI products. First, *Tonburi* has a mutual interaction with the landscape, which is an element of AES. The norms for *Tonburi* production specify appropriate agricultural practices or include measures designed to protect the local environment. Furthermore, the fields where *Tonburi* grows are designated as biologically rich areas; there is a link between a particular landscape and the quality. However, the *Tonburi* region has ceased to value the cultural practices that have influenced the transmission of the TEK of *Tonburi* over the past 400 years. Traditional techniques such as picking and rubbing of seeds by hands, and original production processes such as boiling, sterilizing, drying, pealing, and draining raw seeds, are threatened.

4. Results

In this section, the historical changes in cultural capital and natural capital of the *Tonburi* production areas are provided.

4.1. Cultural capital: transition of Tonburi knowledge

Agricultural management practices are subject to societal demands for the outcomes from the change of cultural capital and productive agricultural practices. To substantiate and validate such interlinkages of agricultural practices and cultural capital, we described in chronological order how TEK affected a rural community (including farmers and agricultural cooperatives) and their prevailing social interactions, norms, and value settings (represented as an integrative element in the process of *Tonburi* production) with the case study of a small GI farm in Odate City, Akita. We found that the small GI farm was embedded in

Table 1
Functions of cultural capital and natural capital.

Cultural Capital (Bennett et al., 2018)	The presence of processes to maintain connections to place, traditional ecological knowledge, practices, and artifacts that are central to a group's identity and support stewardship	
Natural Capital (Haines-Young et al., 2006)	**Regulation functions:** maintenance of essential ecological processes and life support systems	-Climate regulation, water supply, soil retention/formation, biological control
	Habitat functions: providing habitat (suitable living space) for wild plant and animal species	-Maintenance of biological and genetic diversity

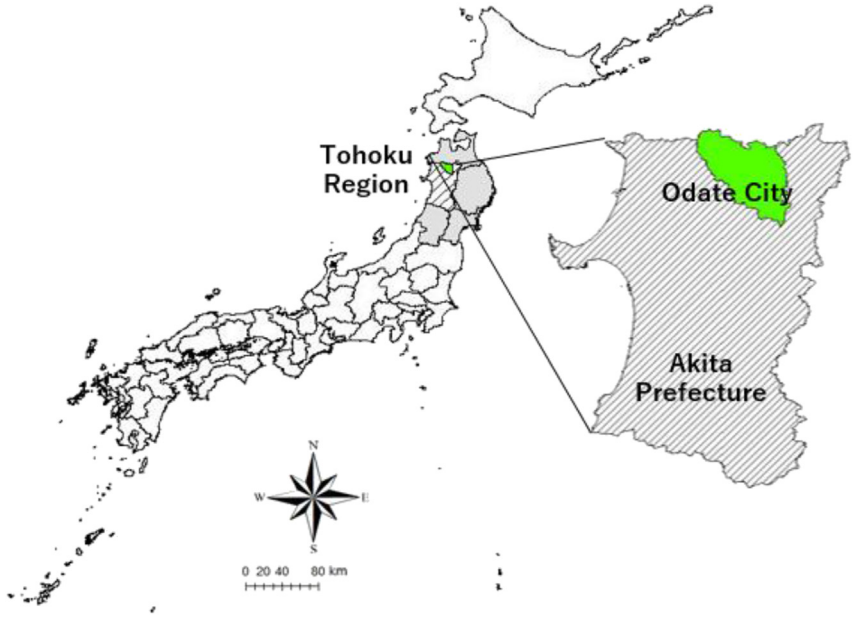

Fig. 1. Map of study area.

the context of territorial dimensions (e.g., cultural capital, ecological, and socio-economic scales).

The period from the 1950s to the 1970s was a crisis period for *Tonburi* production. During the first half of the 1970s, Japan's rapid economic growth became sluggish. Local industry in Odate began selling *Tonburi* as tasty bites in 1974. It had previously been recognized as a local food in Akita, but as sales channels expanded, it spread nationwide. The promotion and management of local products and related

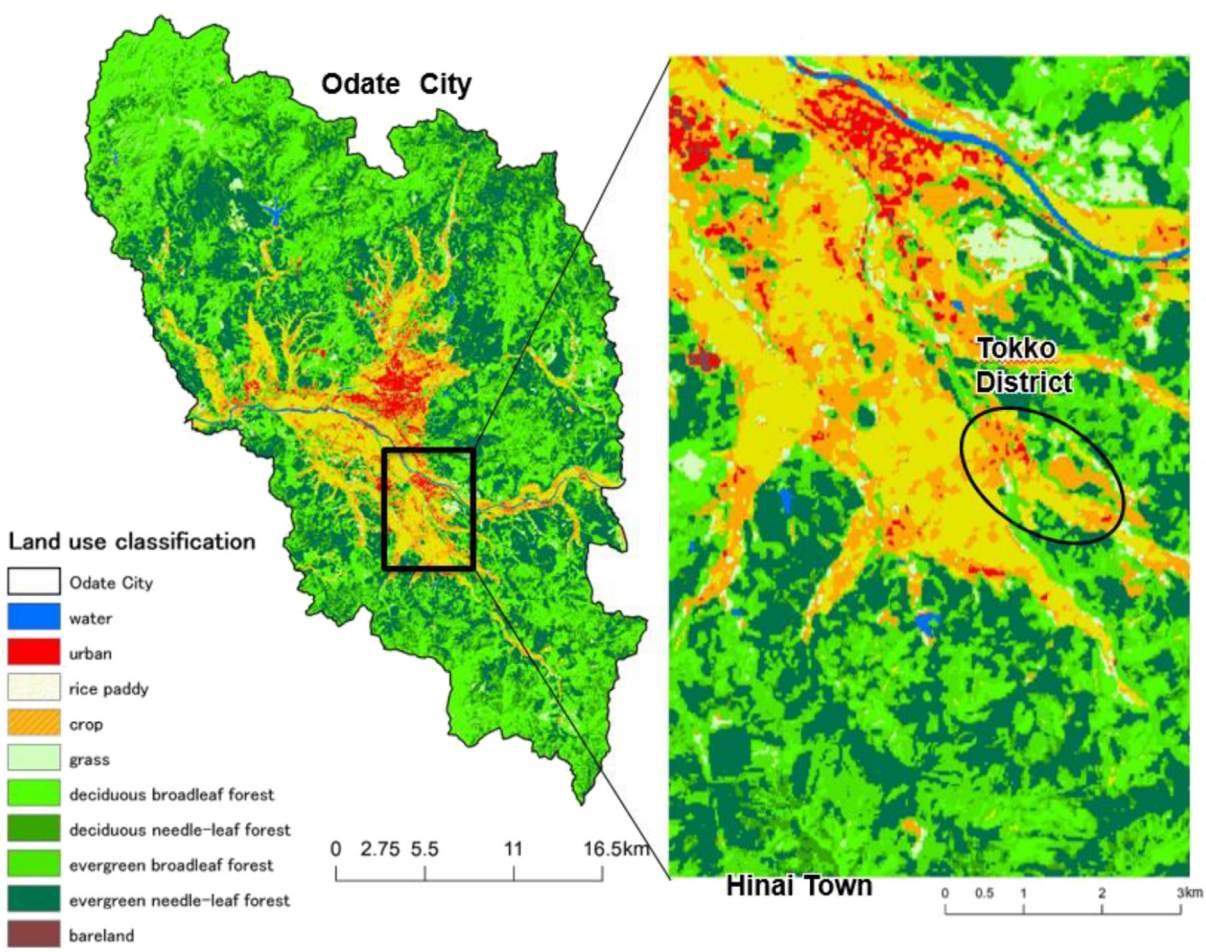

Fig. 2. Land use classification in Odate. The data was obtained from ALOS, EORC, JAXA.

employment was a critical issue for the local agri-system. Traditionally, Odate and the surrounding areas had been occupied with mono-culture of rice production. With the lowering demand for rice, depopulation started and this resulted in a vicious circle where lack of young people resulted in an imbalance in the community: a large number of farmers and their successors had to work in urban areas to compensate for their lost income (called *Dekasegi)*, which led to a loss of vitality. To address this, the city embarked on *Tonburi* production to secure the workplace and evoke local identity amongst producers. Yet, TEK was not shared among producers, and as a result, *Tonburi* seed picking remained a physically challenging task for the farmers during this period. There was limited governmental support for *Tonburi* due to the ongoing recession at the time.

The period from the 1980s to the 1990s was the turning point for *Tonburi* production. Reflecting on the needs described above and on the requests from residents, JA *Akita Kita* staff were keen to use local resources (including human and natural capital) along with historical resources for rural development, and an opportunity came by with Japanese rapid economic growth. "The 1980s witnessed a gourmet boom: delicacies such as caviar and sea urchin were in high demand. Recognizing such opportunities, Odate City started promoting *Tonburi* cultivation amongst farmers. Farmers responded and began to cultivate *Tonburi* as a rotation crop, and JA *Akita Kita* fostered the development of skills in processing the seeds and the use of a vacuum packing apparatus. Prior to this, farmers were planting *Kochia* by hand. During the 1980s, farm machines started planting Kochia in the *Tonburi* fields and the workload of the elderly was reduced. The emotional pressure in the residents' lives diminished, and it became possible to sell the products throughout the year. *Tonburi* factories increased in number from the 1970s through the early 1990s. With the promotion of *Tonburi* sales, Odate *Tonburi* became well-known domestically as a local brand. As a result, the overall crop acreage expanded from 40 ha in 1980 to 95 ha in 1990. In 1990, there were 138 *Tonburi* farmhouses and production reached 410 t. This expansion permitted the stable shipment of *Tonburi*. In 1996, the output value was 115.440 million yen or approximately one million USD. *Tonburi* production largely supported the local economy during this period.

The period from the 2000s to the GI registration saw the steepest decline in *Tonburi* production. During this period, agri-stewardship assets began to malfunction. A challenge arose in the continuity of *Tonburi* production: the number of *Tonburi* farms gradually declined from the 1990s (Fig. 3). The amount of production decreased to 70 t in 2016.

The number of farmhouses decreased to 11 and the cultivated area decreased from 95 ha to 20 ha. Reasons for this decline include the fact that *Tonburi* was a minor vegetable and demands were unstable. Production planning was difficult for the farmers. Under market pressure caused by *Tonburi* produced in China (frequently at a lower cost), farmers and retailers of Odate *Tonburi* struggled to maintain the product's price. The residual income of farmers also decreased. With these challenges, successors of these farmers expected difficulty in making their living from *Tonburi* production and the number of farmers decreased. Simultaneously, the average age of the *Tonburi* farmers was increasing: as of April 2018, only two farmers were in their 30s while the remainder were in their 60s and 70s.

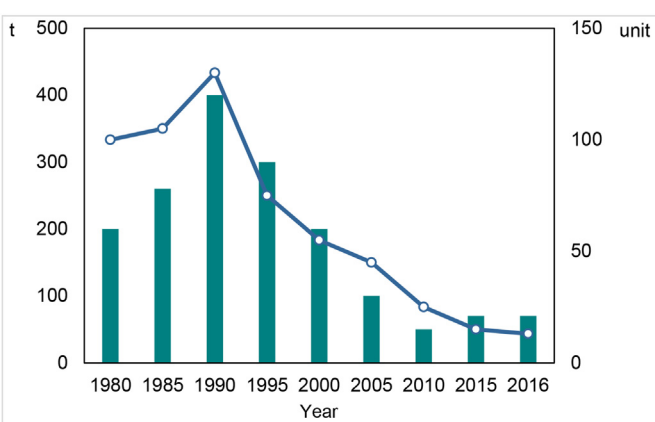

Fig. 3. Amount of Tonburi production (t) and. the number of production units from 1980 to 2016.

This drove a *Tonburi* production crisis, and the number of abandoned farmlands increased in the absence of successors. Thus, farmers were unable to transmit their agricultural knowledge to future generations.

In this context, the staff of the local farming organization, JA *Akita Kita*, explored measures to overcome the decline in the production of *Tonburi* and established a strategy to increase the number of new producers. The JA believed that there was an opportunity, as traditional vegetables had become popular during that time (Kohsaka, 2017; Uchiyama et al., 2017b). JA *Akita Kita* decided to register a GI to boost regional development. They believed that through GI registration the quality and value of *Tonburi* could be defined and assessed, based on its long history and interaction with the landscape.

As a concrete step, JA *Akita Kita* proposed their plan of GI registration to *Tonburi* farmers. After long negotiations, *they* agreed with the farmers on the following conditions: the farmers agreed to unveil the hidden techniques and skills of *Tonburi* and share them with new producers, and JA *Akita Kita* proposed two supportive measures as follows:

- Secure human resources to stably produce and sell *Tonburi*
- Sustainable support and an effort to ensure stable farmer income

The interviewee for this study, a representative of the *Tonburi* department of JA *Akita Kita,* reflected on the difficulty of persuading the farmers to provide their knowledge for registering *Tonburi* as a GI product. JA *Akita Kita* applied for GI registration in July 2016 after several rounds of discussion with the farmers, and *Tonburi* was designated as a GI product on May 26, 2017.

After GI registration in May 2017, *Tonburi* production was revitalized according to JA *Akita Kita*. Specific changes were observed among *Tonburi* farmers. For example, TEK as a function of cultural capital, the secrecy of which had previously worked against the continuity of *Tonburi* production, began to be shared. To transfer traditional skills and expertise from predecessors to new producers of *Tonburi*, the farmers polished their techniques and cooperated with the newcomers.

Support by JA *Akita Kita* was initiated, and JA *Akita Kita* purchased *Tonburi* from the farmers and sold it in smaller sizes and packets to make the initial purchase more affordable to consumers. The *Tonburi* stock ready for shipping in 2016 was sold out by May 2017.

Among GI products, Odate *Tonburi* is unique because of its small-scale production and it is a minor vegetable. The registration as a GI product was primarily motivated not by economic reasons but rather to protect and continue producing local products. Regarding the conservation of the linkage between the local landscape, knowledge, and production, GI registration is an effective means for stakeholders to avoid the extinction of *Tonburi* as a traditional local product.

4.2. Natural capital: dynamics of agricultural landscape management

Agricultural landscapes as socio-ecological aspects are shaped over time by agricultural management. In section 4.2, we identified the change of agricultural landscape policy related to the effects of natural capital and the long-term ecological sustainability of the *Tonburi* production, concerned with the spatial variation of the biophysical capacity with the aim of covering broad geographic, socio-economic, agricultural landscape contexts (Table 2).

From the results of the in-depth interview of the representative of

Table 2
Natural capital approach to transform the context of agricultural land cover management.

Natural Capital	The emergency of Tonburi production period (1950s-1970s)	The turning period of Tonburi production (1980s-1990s)	The decline age of Tonburi production (from 2000s to GI registration)	After GI registration
Regulation functions				
Climate reguration typhoon		Typhoon frequently occurred →	Large scale typhoon →	
		Plant seeds in late April cultivated in mid-October →		
		Early/ middle/ late ripening →		
Water Supply /retention		Consolidate Water channels		
	Use spring water of Mt. →	Steam water →	Pump spring water	
Soil retention/ formation	Make the route for flowing water	Soil got hard, cultivators →	Analyzed soil constitutions →	Human power and cultivators
			Abandoned lands increased	
			Soil harder →	Mitigated hard soil
Biological control	Apply herbicide (a little) →	Armyworm increased →	Fitted herbicide (organic) →	Organic pesticide refrained
Habitat functions				
		→	Hymenia recurves	
Biological and genetic diversity	Foxes, sly foxes, and weasels →		Bears →	
		Seeds of acacia, beech, and cicada		
		Winds flowed trees →		

Tonburi farmers, it was determined that the knowledge of *Tonburi* production is intimately related to ecological agricultural landscape management. Table 2 summarizes the natural capital approach to transform the context of agricultural land cover management through the last 60 years.

During the crisis period of *Tonburi* production (1950s–1970s), the production amount depended on climatic conditions. Even when a typhoon hit *Tonburi* fields and caused damages, nearly 20–30% of the *Tonburi* could still be harvested owing to the cedar forest surrounding the fields, and therefore, the farmers did not take any action. However, they took several steps to adapt to the natural environment. For water supply, they used spring water from the mountains; for soil retention, they constructed drainage routes to maintain the soft soil. They introduced cattle or horses equipped with *Kakaemottatesuki* (a type of Japanese plow without a sole). Labor productivity also increased, while land productivity improved through work-force-intensive agricultural techniques. For biological control, farmers used an local herbicide concocted by blending organic weedicides, but the amount used was minimal.

Regarding habitat, small animals such as foxes, sly foxes, and weasels appeared in the fields but did not harm the Kochia. Therefore, farmers did not implement any measures for animal control. People and small animals coexisted during this period.

During the turning period of *Tonburi* production (the 1980s–1990s), farmers adapted to local climatic conditions. They planted Kochia seeds in late April and harvested during mid-October to avoid the strong wind of typhoons. They moved the cultivation dates of three types of Kochia, including early-ripening, middle-ripening, and late-ripening. Even if a typhoon damaged the first and the second types, they had the option of cultivating the third one. Regarding water supply, the farmers' adaptation negatively affected the agri-environment. A tremendous natural disaster occurred during this period. Water channels were constructed using concrete for fireproofing. As a result, spring water diminished. Thus far, farmers had rinsed seeds of Kochia using spring water, but they had to change to a location with a stream. Relatively strong winds during this period frequently blew seeds of acacia, beech, and cicada trees into *Tonburi* fields. Farmers struggled to eliminate these seeds. For soil retention, along with a production increase, they had to depend on a few pesticides and agricultural chemicals for efficient production. The other challenge was the hardening of the soil. Because of the limited manual labor with a small-scale production, they had to depend on cultivation machines. Armyworm increased in this process because of the use of organic herbicides.

During the declining period of *Tonburi* production (from the 2000s to GI registration), the frequency of typhoons decreased but their scale expanded, and a relatively large number of Kochia seeds fell on the ground. This was a significant loss for farmers. The soil hardened annually because of the herbicides, decrease in the number of farmers, and mechanization. To understand the hardening, farmers began to analyze the soil constitution in the fields. They changed organic herbicides and a new pest, similar to the *Hymenia recurvalis* (Fabricius), appeared and flourished. Small animals disappeared from the *Tonburi* fields and the appearance of bears became common. Bears did not damage the Kochia seeds, but they passed through the fields and distributed them.

After GI registration in 2017, a strategy for sustainable *Tonburi* production and conservation of *Tonburi* fields was implemented, addressing a change in the agricultural environment. For water supply, along with the building of processing locations, farmers were able to pump spring water. For soil retention, farmers plowed using human labor for the first step of cultivation and then used cultivator machines to create environmentally friendly soil. Farmers also refrained from using organic pesticides. TEK applied to the agricultural landscape ecology had changed as the landscape changed with small farm innovation. In this sense, GI registration contributed to these changes in the case of *Tonburi*. The function of ecological land in the *Tonburi* fields had a time dimension. TEK transition resulted in farmer's agri-environmental management based on the ability to deal with particular benefits or services, such as biodiversity or other outputs from the agricultural landscape.

4.3. Cause-effect relationship between cultural and natural capital

Exploring the evolution of both cultural and natural capital related to Tonburi production has revealed that regeneration and creation of TEK in cultural capital could be beneficial to a rural community, where TEK is an inherent part of the agri-environmental landscapes. We demonstrated how locals (*Tonburi* farmers, stakeholders, and JA *Akita Kita*) socially interact with environmental processes and natural capital. Furthermore, we identified that efficient landscape management practices required the capability of rural community and governance structures in natural capital valorization. The cause-effect links between cultural and natural capital promoted the community's understanding that the management of agricultural landscape brings social benefits including rural vitality, development, and economic performance. The transformation of the landscapes and farmers' TEK, as well as the interaction of these factors, caused the change of *Tonburi* production in Odate. Besides, GI registration activities influenced the cultural capital and natural capital (directly and indirectly), implying a cause-effect relationship between them. In particular, the impacts of the GI

registration process were observed in the status of TEK such as Kochia processing methods, which had been shared in individual communities in the past and were being shared among all *Tonburi* farmer communities, including newcomers, after GI registration. In other words, the GI process itself served as a catalyst to open the knowledge sharing from enclosed family members to the members of community. During the process of knowledge-sharing, the relationships between farmers and natural capital changed again in the context of nationwide climate change.

GI production is rooted in creating value from landscapes. However, the importance of non-marketable, socio-cultural, and ecosystem services outweighs the importance of agricultural production, as we have seen in the process. Region-specific variations of cause-effect relationships are related to biophysical conditions, land-use patterns, and agricultural management. In this sense, the local perception of GI location connects a multi-dimensional measurement of environmental values according to the agricultural landscape level.

5. Conclusions

We examined a case in Asia, where the GI system has been adopted recently by several countries. Existing empirical studies mostly include a few case studies of GI products in Europe that analyze traditional characteristics and linkages between products and designation areas from the perspectives of landscapes and AES. While empirical studies have largely overlooked the relationships between TEK and landscapes for GI products, this study attempted to trace the transition and change in natural capital and cultural capital based on case analysis of a GI product. This paper can be positioned as literature on the association between AES and GIs, and it identifies the long-term changes regarding the cultural capital and natural capital of the farming system of *Tonburi*.

This study found that the case of *Tonburi* demonstrates a cause-effect relationship between TEK and agricultural landscapes: the technical practices embedded in TEK flexibly adapted to the changing biodiversity in the *Tonburi* fields and the knowledge also helped in maintaining agricultural landscapes. Considering the role of the GI scheme as a catalyst, this research demonstrated that the relationships between changing agricultural landscapes and TEK are closely related to *Tonburi*'s registration as a GI product. The GI registration process functioned as a catalyst for the knowledge-sharing process.

This study also found that the farmers did not share their TEK and processing skills with JA *Akita Kita* until the GI registration of *Tonburi*. This trend negatively affected regional *Tonburi* production: Although JA *Akita Kita* asked the farmers to share the TEK with new producers before the process of registration, the farmers did not accept the recommendation. As a result, the productivity and resilience of the smallholder producers weakened amid rapid aging and decreased number of farmers. Moreover, the increase in abandoned fields degraded the agricultural landscapes of the *Tonburi* production areas.

To address this vicious cycle, JA *Akita Kita* used the GI registration as an opportunity to persuade the farmers to convey their TEK, and the farmers accepted their proposal. The farmers not only conveyed TEK of skills and means of production but also of management and adaptation to agricultural landscapes. Furthermore, the farmers believed that the conservation of the *Tonburi* fields and surrounding agricultural landscapes led to enhancement of productivity and sustainable *Tonburi* production. Thus, it can be said that the *Tonburi* farmers implemented agricultural landscape conservation like AES. The scheme of *Tonburi* production was implemented under cultural capital (TEK) and natural capital (landscapes).

Without managing ecosystems or the biophysical aspects of an agri-environment with relevant knowledge, the farmers could not increase their production. The case study of *Tonburi* demonstrates that agricultural landscape management with GI products can facilitate local stakeholder collaboration such as the sharing of TEK via GI registration and utilization processes. We identified that the GI process served as a catalyst to open the knowledge sharing from enclosed family members to the community members.

Previous case studies of AES in the EU and other regions suggest that supporting small farms is necessary for rural development policy, particularly in post-industrial societies where product differentiation is critical (Guedes and Silva, 2014; Zasada et al., 2017a; Zhu et al., 2018). Lange et al. (1999) and Pascucci et al. (2013) have provided evidence that farmers are well aware of landscape potential and accordingly adopt agri-environmental strategies as tourism strategies. However, this study shows that *Tonburi* farmers have managed their production fields and maintained agricultural landscapes without collective tourism strategies. They have harmonized local cultures, traditions, and agricultural landscapes without any regulation or intervention from a local government. In this regard, considering and based on previous studies of AES (Haines-Young and Potschin, 2010; van Zanten et al., 2014), the results of this study provide evidence of the potential of GI farms under changing landscapes and TEK status.

As for the applicability of this research method, we will conduct a comparative analysis of cases in different regions of the world to develop a more generalizable framework and to provide lessons for future research. Theoretically, there is a need for future research on testing of hypotheses around several elements of the stewardship framework (Borin et al., 2006; Bramley et al., 2009; Lim et al., 2004; Thanasis et al., 2017). In this study, the integrated analytical framework for GI scheme, which encompassed essential aspects of agricultural landscape management, demonstrates the linkage between cultural and natural capital at the landscape level (Guerry et al., 2015; Rangnekar, 2003). Our study reveals the impact of small GI farm production on TEK and landscape and considers entry points for rural innovation that promote landscape valorization.

Acknowledgement

This work was supported by the JSPS KAKENHI Grant Numbers JP16KK0053; JP17K02105; JP17H01682; JP17H04627; Research Institute for Humanity and Nature [No. 14200126]; Toyota Foundation [D17-N-0107]; Ministry of Agriculture, Forestry and Fisheries [Policy Science Research Project 2018].

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jrurstud.2019.03.014.

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