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Evaluating plant genetic diversity maintained by local farmers and residents: A comprehensive assessment of continuous vegetable cultivation and seed-saving activities on a regional scale in Japan

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Abstract.
The practice of saving seeds from local varieties of crops and vegetables is integral for preserving agricultural biodiversity. After reviewing the current (1) seed saving activities practiced worldwide, (2) agricultural industry and farmer behaviour in Japan, and (3) seed system used in Japan, we conducted a survey to determine methods for the cultivation of homegrown seeds on a regional scale. Questionnaires were mailed to 7,068 families (including full-time and part-time farmers and home gardeners) in the Noto Peninsula, Ishikawa Prefecture, Japan, and 1,662 responses were obtained. We found that a majority of the respondents purchased seeds; however, some seeds were grown locally, and were mostly homegrown. Contrary to general expectations, the economic incentive ("good market price") played an insignificant role in crop cultivation continuity.

Cluster analysis resulted in four groups of crops, according to the rate of on-farm seed saving and changes in cultivation over a 30-year period. Certain crops, such as soybean and azuki bean, were frequently grown using on-farm produced seeds. Different conservation strategies were required for crops in each cluster due to their unique characteristics. Our data form the basis for promoting diversity and local crop cultivation by farmers in industrialized countries.

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Introduction

Agricultural bio-diversity is based on the genetic diversity of crops and vegetables. Historically, this diversity was maintained mainly via seed saving activities, by local farmers. The sustainable use of seeds is gaining salience in light of the focus on food security, food sovereignty, agricultural biodiversity, and conservation of traditions and cultures.

The Food and Agriculture Organization (FAO) has been evaluating sustainable seed use and farmer contribution. The contributions of small and family farmers to agricultural stability worldwide have been analysed and highlighted. International frameworks, including Aichi Target (especially Target 13, on genetic diversity of cultivated plants, farmed and domesticated animals, and wild relatives), under the Convention on Biological Diversity and SDG target 15, have addressed the loss of biodiversity. The loss in the genetic diversity of agricultural products is extensively related to food security and farmer income.

Investigative studies on seed conservation networks and seed exchange have been actively conducted worldwide, in locations such as Europe, the United States, Asia (India and Nepal), Africa, and South America. Some studies conducted in recent years enumerate upon the importance of seed exchange networks (Almekinders et al. 1994, Campbell 2012, Coomes et al. 2015, Helicke 2015, Pautasso et al. 2013), their potential to attach new values to local varieties, and become the starting point of radical social change (Balázs and Aistara, 2018). Additionally, studies on the status of on-farm seed saving activities have yielded considerable results in places such as Britain. However, it is considered difficult to quantitatively determine the extent of on-farm seed saving activities of farmers in regional areas (Hisano, 2012). In order to understand diversity and sustainability in regional agriculture thoroughly, and plan measures for the future, it is necessary to obtain a realistic assessment at a relatively large scale, by quantitatively determining the extent of diversity and crop cultivation continuity, using indices such as rates of on-farm seed saving. This analysis would be integral in improving agricultural sustainability worldwide, particularly for countries exhibiting progress in agricultural modernisation. In particular, an analysis of sustainable agriculture during the monsoon in Asia, which has one of the largest populations in the world, would enable us to gain knowledge and understand food systems worldwide. The present study will focus on Japan, which has been ahead of other Asian countries in terms of agricultural industrialization.

Among the countries in Asia, agricultural industrialization progressed during a relatively early period in Japan. This progress involved mechanisation, development in varietal improvement, and the spread of the use of agricultural chemicals. Factors pertaining to productive technology were also accompanied by a shift towards large-scale distribution, a shift to varieties compatible with distribution, and shifts in the tastes of consumers. Thus, local varieties of crops began to rapidly disappear from the 1980s onwards in Japan. Farmers began to purchase seeds from seed shops instead of using homegrown seeds. Meanwhile, the recent years have seen a trend sometimes called the ‘traditional vegetable boom;’ it caused the value of local varieties that had fallen into disuse to be newly recognised. Yet, it is unclear if such a boom would contribute to the maintenance and sustainable use of cultivated plants exhibiting genetic diversity. The thorough analysis of the present situation in Japan would enable us to understand the losses in agricultural biodiversity that neighbouring Asian countries would probably occur in the future. Prior studies regarding on-farm seed saving activities of farmers have focused mostly on a single crop, variety, seed exchange network, social movement, or NGO, and rights of farmers; none have comprehensively analysed the diversity of crops across an entire rural region.

Therefore, the present study would examine the characteristics of crop cultivation by farmers and non-farmers in the Noto region of the Ishikawa prefecture, which is a depopulated region in Japan, to shed light on the status of on-farm seed saving activities and factors contributing to their continuation. First, we will review seed conservation in different countries in the world. Next, we will shed light on historical transitions in the structure of the agricultural industry in Japan and its shift towards part-time farming, taking into account some arguments by researchers such as Mulgan (2006) and Jussaume (1990, 1991, 2003). Then, we will summarise results of prior studies regarding seed saving in Japan. Then, we will outline issues and develop an analytical framework. Based on the reviewed content, the developed analytical framework, a questionnaire survey would be conducted with farmers and residents of the Ishikawa prefecture. The obtained results would be statistically analysed and the status of diversity in crop cultivation in rural regions and factors contributing to their continuation would be discussed thereof. Finally, we will examine the characteristics of on-farm seed saving and consider conservation strategies tailored to each crop group.

(1) Literature on seed saving, seed exchange, and seed systems in the world

During the mid-twentieth century, many farmers worldwide began to abandon on-farm seed saving due to the oligopoly of seeds sold by seed companies (Kloppenburg, 2010; Howard, 2015). This led to serious losses in crop diversity in industrialized areas, such as Europe, North America, and Japan. Although seed governance differs between staple crops and vegetables in Japan, few systematic analyses have considered such differences. The context-specific analysis of differences in governance regarding regions or crops is also necessary. Despite recognizing the importance of genetic diversity in agriculture (Pautasso et al., 2013), farmers increasingly rely on seed companies and use improved varieties of seeds.

In general, genetic diversity is maintained in the global South (southern hemisphere), by the cultivation (conservation) of local varieties (landraces) by farmers. Meanwhile, genetic diversity of vegetables is maintained in the Northern hemisphere by committed seed savers at allotment gardens, who save and circulate heterogenetic, 'legacy' variety seeds (Gilbert, 2013). In Europe, small-scale seed production by a network of collaborative organic farmers and gardeners (grassroots organisations) has contributed to the conservation and utilization of agricultural biodiversity (Vellvé, 2013). However, the varieties grown by these farmers and gardeners are frequently produced in regions different from their origins (Nemoto and Nishikawa, 2008). Non-profit organizations (NPOs) and gene banks have also served as informal institutions for maintaining seed circulation in the EU (Imaizumi, 2012). Thomas et al. (2012) performed ethnobotany and population genetic studies of bread wheats in France and found that a comparable seed diversity was observed in both NPOs and gene banks. This suggests that farmer-led seed diffusion plays a key role in conserving agricultural biodiversity. Thomas et al. (2012) also concluded that on-farm practices are complementary to gene bank systems and can lead to efficient diversity conservation. Similarly, Jarvis et al. (2008) found that farmers select varieties to ensure diversity, according to their current needs and purposes.

Let us further analyse seed governance in Europe and the farmer response to it. In Europe, production and marketing of seeds are strictly regulated by specific seed trade and variety protection laws (Da Via, 2012). The Union Internationale pour la Protection des Obtentions Végétales (UPOV) was implemented in 1991 and the application of plant breeders' rights to cultivation of homegrown seeds at farms began, and this was met with staunch opposition movement in Europe (Da Via, 2012: p234). It is still common for small farm households to select

varieties through cultivating crops from seeds obtained in the market; these 'farm-saved seeds account for 50% of self-fertilising crops in France (Kasteler, 2005).

Da Via (2012) and Balázs and Aistara (2018) have examined the characteristics and significance of seed exchange networks in Europe. Balázs and Aistara (2018) have used the TSI framework (transformative social innovation) to analyse seed exchange networks. Specifically, the study discusses the addition of new values to seeds based on the results of qualitative interviews held with NGOs in Europe. The discussion section states that seeds, in the material sense, fulfil the role of an intermediary, integrating people, ideas, and networks across sectors. The value of participants of such networks as entities that redefine social relations and create models of learning, behaviour, framework, and organisation are discussed. However, Helicke (2015) has analysed seed exchange in the United States and asserted that the development of a resilient seed system depends on 'how the innovative and isolated engagements by experts and farmers could be expanded and connected with broader networks'.

Campbell (2012) examined the reintroduction of open-pollinated seed exchange (seed swap) in the United States. Jordan (2007) analysed transitions in discourse and the social 'significance' attached to the conservation of heirloom tomatoes in the United States, from the viewpoint of tomatoes as cultural objects. The study highlighted the possibility of coexistence of providing commercially cultivated heirloom tomatoes at expensive restaurants in New York (commercial value and branding) and the continuation of their conventional cultivation at local farms and household vegetable gardens.

Next, we shall review the status of conservation in developing countries mostly located in the global South. Rana et al. (2007) has shed light on the characteristics of on-farm conservation of local rice varieties in Nepal. Specifically, the study showed that the on-farm conservation of rice landraces would largely depend on market dynamics, and that there are only a few landraces that have socio-cultural and religious values. Poudel et al. (2015) has analysed dynamic changes in networks on a time series, and the roles of the 'central members' of the network in Nepal. The results revealed that the 'nodal (central)' farmers brought in new varieties from outside their region and distributed various seeds to other farmers in their communities. The results also revealed a characteristic feature of nodal farmers; they did not receive seeds from members of their communities. Additionally, the results revealed that older people had a tendency to obtain seeds from their own crops, and younger people had a tendency to seek, obtain, and use newer varieties through exchange (Poudel et al., 2015). Almekinders et al. (2007) suggested that cultivars from participatory plant breeding activities improved the provision of seeds to small-scale farmers.

Consumers also participate in guided seed exchange; in Kenya, for example, the consumption of exotic vegetables was once considered "modern" but local varieties have recently regained favour due to public awareness (Irungu et al., 2007). Increased plant diversity can improve productivity (Di Falco et al., 2010), pollination, and soil nutrients (Hajjar et al., 2008).

With regard to crop wild relatives (CWRs), in situ conservation systems have emerged without the planned, systematic interventions of modern science (Montenegro de Wit, 2016). However, in developed countries, there are no CWRs, and strategies for conserving agrobiodiversity need to be analysed. Nazarea (2013) reviewed both biological and social scientific studies with regard to the conservation of agrobiodiversity, and analysed the different positions of these scientists. Discussions about plant genetic resources should focus on the conservation of traditional agricultural knowledge and plant resources. The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) addressed this topic; however, developed

countries were not held responsible for maintaining crop biodiversity (Brush, 2007). Hayashi (2010) and Mori (2011) investigated the access, shared benefit, and biodiversity relationships at the international community level, but Nishikawa (2010) reported that plant diversity has not been sufficiently discussed by the international community. Greater efforts are therefore necessary, to gain knowledge concerning the biodiversity of local crop varieties on a global scale.

Berg (2009) indicated that the importance of landrace varieties was only recognized when "modern" varieties of cereals were introduced to European farmers in the late nineteenth century. After analysing previously published data, Zeven (1998) proposed a working definition of landraces, but recognized that a comprehensive definition of the term is not possible due to the complexity of landraces. Similarly, there is no globally accepted definition for "local variety", although it can be defined as a line of seeds that has been traditionally cultivated by farmers. Quantitatively determining on-farm seed saving and informal seed conservation is considered difficult (Hisano, 2012) because some farmers might not recognize their own seeds as local varieties. The terms "local variety" and "primitive variety" are often replaced with less well-defined terms, such as native variety, traditional variety, or farmers' variety. Tripp (1996) emphasized that local varieties are not stable ancient germplasms, but have been developed by the long-term propagation of useful or attractive qualities (Table 1). The term "landrace" is used to indicate local endemic varieties, including vegetable varieties (Nishikawa, 2005). Nazarea (2005) used "heirloom seeds" or folk varieties to highlight the contribution of farmers and gardeners who save, propagate, and distribute these varieties.

Table 1. Definitions of local varieties

Author/ Organization (year)	Term	Definition	Comment
Tripp (1996)	Local varieties	Products with a wide range of characteristics are carefully selected by farmers. These are not unchanging embodiments of ancient germplasms, and represent the outcomes of imperfect and iterative choices of qualities judged to be useful or attractive at a particular time point.	Defined by comparison with modern varieties
Zeven (1998)	Landrace	A variety with a high tolerance for biotic and abiotic stress, with a high yield stability and intermediate yield level, under low-input agricultural systems.	Referring to the definition by Mansholt (1909)
Watson(1996)	Heirloom	The variety must have been introduced more than 50 years ago.	See also Jordan (2007)
Hyogo Landrace Conservation Association (2003)	Landrace	Varieties or accessions of crops and vegetables grown at several local sites, cultivated by farmers for several generations, and supplied for a specific way of cooking or processing.	Non-profit organization (NPO) in Japan

Yamagata Heirloom Vegetable Research Association (2003)	Heirloom vegetable	Cultivated plants, including vegetables, fruits, crops, etc., that have been cultivated at the same site for a long time and gained popularly with local residents.	Non-profit organization (NPO) in Japan
Ujihara and Matano (1974)	Local varieties	Crops (in this case, buckwheat) that have been cultivated, with seeds saved at the same site, for more than 20 years.	Japanese local varieties of buckwheat were collected, and their characteristics were analysed

Crops and vegetables used in traditional food cultures have changed with the introduction of improved varieties. These changes have resulted in a rapid decline in the cultivation of local varieties and a gradual biodiversity reduction in the farmer seed system. Moreover, while sustainable farming of local varieties is considered important for maintaining plant genetic resources and agricultural biological diversity (Mooney, 1979), farmers generally do not cultivate local varieties solely for their preservation. Farmers' seed exchange networks are considered important for sustaining local varieties and there has been interest in their improvement (Coomes et al., 2015). Pautasso et al. (2013) reviewed several approaches for conserving traditional crop varieties and suggested the integration of different methods to address the challenges associated with retaining landrace varieties. Further, institutions such as the Group for Conventional Preservation and the Seed Savers Network have been established, to promote the conservation and utilization of existing local varieties (e.g. Australia, India, and Japan).

(2) Structural characteristics of part-time farmers, the main component of the agricultural workforce in Japan

In Japan, farming is carried out at a characteristically small scale. The number of abandoned fields have been increasing as the 'bearers' (*'ninaite';* the main, solid component of the agricultural workforce of Japan) age and decline in number. Meanwhile, the decline in the number of part-time farmers has caused a slight increase in the average farming area. Historically, agriculture centred on rice paddies was omnipresent in Japan, and communities were formed around the framework of irrigational management for rice paddies.

Due to the socioeconomic and political factors arising after World War II, small farm households began to take on side jobs, and became part-time farmers. According to Jussaume (1990, 1991), the shift towards part-time farming in Japan had been supported by rural industrialisation and subsidies.

Farm households had chosen to take on side jobs and become part-time farm households, to deal with changes that occurred in post-war rural communities in Japan (Jussaume, 2003). Through this shift, the proportion of non-agricultural income grew within the income of farm households, making them less dependent on agriculture.

Until then, part-time farm households had been criticised because of the common view that they received undeserved income. However, QOL analysis did not support the supposition of the

neoclassical argument that 'part-time farmers received undeserved income through agricultural protection (Jussaume, 1991). Rather, full-time farmers and Type I (mainly farming) part-time farmers had low QOL in the physical sense, while they had a high social QOL. Thus, in comparison to non-farmers, farmers have lived in 'harsher' environments.

This study by Jussaume focused on a period spanning from the 1960s until the 1990s. It involved a detailed investigation (micro) to reveal the status of agricultural settlements and conducted a survey covering the Okayama prefecture, shedding light on the shift to part-time farming in Japan and its underlying factors.

Let us now take a look at data regarding fluctuations in the total number of farm households in Japan and its breakdown from 1990 to 2015 (Table 2). The breakdown covers 'non-commercial farm households' and 'non-farm households that owned cultivated land' in addition to the 'full-time farm households' and 'part-time farm households,' as observed by Jussaume (1991, 2003).

Table 2. Changes in the total number of farm households and their categories (1990 to 2015; unit: household)

	1990	1995	2000	2005	2010	2015
Total farm households	3,834,732	3,443,550	3,120,215	2,848,166	2,527,948	2,155,082
Full-time farm households	473,359	427,584	426,355	443,158	451,427	442,805
Type I part-time farm households	520,560	498,395	349,685	308,319	224,610	164,790
Type II part-time farm households	1,976,608	1,725,424	1,560,869	1,211,947	955,169	721,996
Non-commercial farm households	864,205	792,147	783,306	884,742	896,742	825,491
Non-farm households owning cultivated land	775,016	906,176	1,097,455	1,201,488	1,374,160	1,413,727

Source: MAFF (2016) 2015 Census for Agriculture and Forestry

First, the total number of farm households is in a general decline; it has decreased from 3.8 million to approximately 2.1 million from 1990 to 2015 (a decrease by nearly a half). The breakdown shows that the 'Type II (mainly other jobs) part-time farm households', which used to be numerous, have declined to the greatest extent. The number of Type I (mainly farming) part-time farm households has declined in a similar manner. However, the number of full-time farm households has not changed significantly and remained stable; there has been only a slight increase and decrease. This could reflect government policies that supported the 'bearers.' Meanwhile, there has been no significant change in the number of non-commercial farm households either. However, the proportion of 'non-farm households owning cultivated land' has increased yearly, as part-time farm households stopped farming and became non-farm households.

The number of households that are the 'bearers' of 'agriculture as an industry' in Japan have remained relatively constant, and the government has tried to support them. However, part-time farm households, which have supported post-war growth in Japan have declined in number over the years. Many of these hold on to their lands and rent them out as farmland to the 'bearers' in their regions or allow portions to become abandoned agricultural land. However, the number of

non-commercial farm households is probably more than that shown in this data, including for 'residents' farming small-scale 'vegetable gardens' that are not covered by these statistics.

Georgia Mulgan (2006) argued that the protection of agriculture in Japan had been in line with the intention of the Ministry of Agriculture, Forestry and Fisheries (MAFF), to continue their interventions. Hence, prices of rice are currently low due to the free market, and this has contributed to the decline of agriculture, resulting in an increase in the number of 'non-farm households owning cultivated land' that are former part-time farm households that stopped farming but continued to own farmland (Table 2). This trend is salient in areas with disadvantageous conditions for farming, such as Noto Peninsula, and is covered in this paper.

The government and scholars have continuously debated about the category of producers that should be considered appropriate "bearers", and whether this should include all farm households, including part-time farm households or core farm households alone. Debates have generally focused on areas that the government should support and protect. In politics, however, it is important to remain balanced, for politicians to secure votes from farmers. The Democratic Party of Japan administration of 2009 provided 'individual household income support' to all farm households, including part-time farm households, but this ended when the Liberal Democratic Party returned to rule. According to Mulgan (2006), researchers have analysed that a structure built by the Liberal Democratic Party and bureaucrats has persisted. In this structure, the programme by the MAFF has extended its scope from 'agriculture' to the fields of food and rural communities, and in order to turn this into a support system compatible with the WTO, has started providing direct payments to farmers in areas with disadvantageous farming conditions (Mulgan, 2006: p134).

Such measures were based on the idea that farmers and residents of regional communities played an important role in allowing society to enjoy the benefits of the multifaceted functions of agriculture and rural communities, and especially today, ecosystem services.

Since the establishment of the Agricultural Basic Act in 1961, the main goal of agricultural administration was to make agriculture 'large-scale and corporate'. Farmers are believed to have dealt with such changes by becoming part-time farmers. Meanwhile, regarding the 'deskilling,' described by Gilbert (2013), mechanisation has likely caused the 'skills' of full-time farmers to decline as well. In such a situation, the cultivation of homegrown seeds mitigated such 'deskilling' or 'loss of "enjoyment" at fields by farmers due to commercial cultivation and large-scale production'. Seed saving activities at vegetable gardens in Japan could also be understood as an approach of farmers to resist or deal with governmental policies and mechanisation. It is also likely that continued seed saving activities at vegetable gardens in Japan functioned to curb deskilling to some extent.

A decline in the number of part-time farm households and growth in the number of non-farm households owning cultivated land have characterised the agricultural demographics of Japan in the present age. Specifically, the 'bearers' (shortage of 'successors') have become a matter of concern. Table 2 shows that the number of non-commercial farm households has been stable. The farmers of Japan are not fully represented in the 'farm households' in the context of governmental statistics. However, it is likely that, however small the scale, many people would continue to cultivate crops as means to secure food, to provide for themselves, as a means to communicate with residents in the neighbourhood, or for the sense of satisfaction that accompanies farm work. This could lead to the discovery of a factor for the continuation of crop cultivation by non-

commercial farm households, as an extension of the characteristics of the QOL of part-time farm households, as shown by Jussaume (1990) (low physical QOL but high social QOL).

Therefore, one of the pillars of this study is the identification of actors involved in crop cultivation in regional communities, amid the decline of agriculture in Japan in the present age, and the identification of factors for such involvement. The liberalisation of agricultural product imports has caused a decline in the competitiveness of domestic agriculture in Japan. In this situation, the present study hypothesises that non-commercial farm households play a considerable role in the conservation of national land and agricultural biodiversity.

Next, we shall discuss governance with regard to key crops. In 2017, the self-sufficiency rate for soybeans in Japan was approximately 7%. The majority (about 73%) of soybeans were imported from the United States (MAFF, 2019). However; soybeans are one of the crop commodities that are indispensable to Japanese food culture. They are used in products such as miso, soy sauce, and tofu. The government has therefore been providing price compensations to farmers (Mulgan, 2006: p132). However, the 'New Soybean Policy Outline' of 1999 abolished this system and replaced it with a fixed-rate subsidy system. Through this new system, the government tried to boost demand for domestically produced soybeans and promote production and distribution. Nevertheless, the self-sufficiency rate of soybeans as a commodity has continued to decline.

In addition, since the 1970s, the government has implemented policies aimed to make specific regions into producers of specific types of vegetables. This resulted in the selection and favouring of varieties that were more compatible with distribution, which in turn resulted in a drastic decline in crop diversity.

(3) Seed saving activities in Japan

In Japan, the use of fresh, local vegetables has contributed to a healthy and balanced diet and to the development of local food cultures (Inoue et al., 2014). In 2014, Washoku (a traditional Japanese cuisine) was declared to be an intangible cultural heritage by the United Nations Educational Scientific and Cultural Organization (UNESCO). The supply of local traditional foods for preparing Washoku is therefore important for Japanese agriculture (Kohsaka, 2017; Uchiyama et al., 2017). Traditional, locally grown vegetables have been produced and cultivated for generations, and have recently gained popularity and featured in several books and movies (Kusama, 2014).

In Japan, public organizations manage the staple crop seed system as part of the public food policy, whereas private seed companies control the vegetable seed system (Hisano, 1999; Imaizumi and Hisano, 2013). These systems are usually called the "formal seed system." The "informal/ local seed system" or "farmers' seed system" is managed by farmers. The National Institute of Agrobiological Sciences (NIAS) is the largest public-sector plant genetic resource management institution in Japan. As of 2015, 224 thousand plant genetic resources were registered with this organization and more than 5,000 additional varieties have been added every year. Within the private sector, nurseries and food companies also contribute to the management of plant genetic resources. However, the contributions of the private sector are generally skewed toward profitable plants. Moreover, it is difficult to preserve local varieties because they need to be cultivated locally to maintain their integrity and genetics.

Some local varieties in Japan have been branded as "traditional vegetables," and are referred to as "Kyo-Yasai" and "Edo-Yasai." Competing brandings have also appeared, such as "Yamato traditional vegetables" and "Yamato specialty vegetables" (Kodawari vegetables) or

"Noto specially produced vegetables" and "Noto traditional vegetables." Local governments certified these vegetables as "traditional," in order to conserve local varieties, and farmers who continue to grow such varieties are supported by local governments through subsidies, market promotion, or seed preservation in public research institutions. The use of the term "traditional vegetable" provides a brand image that the public associates with increased nutritional value. However, the history, definition, and roles of traditional vegetables vary among regions (Table 3).

Table 3. Traditional vegetables characteristically found in various regions of Japan

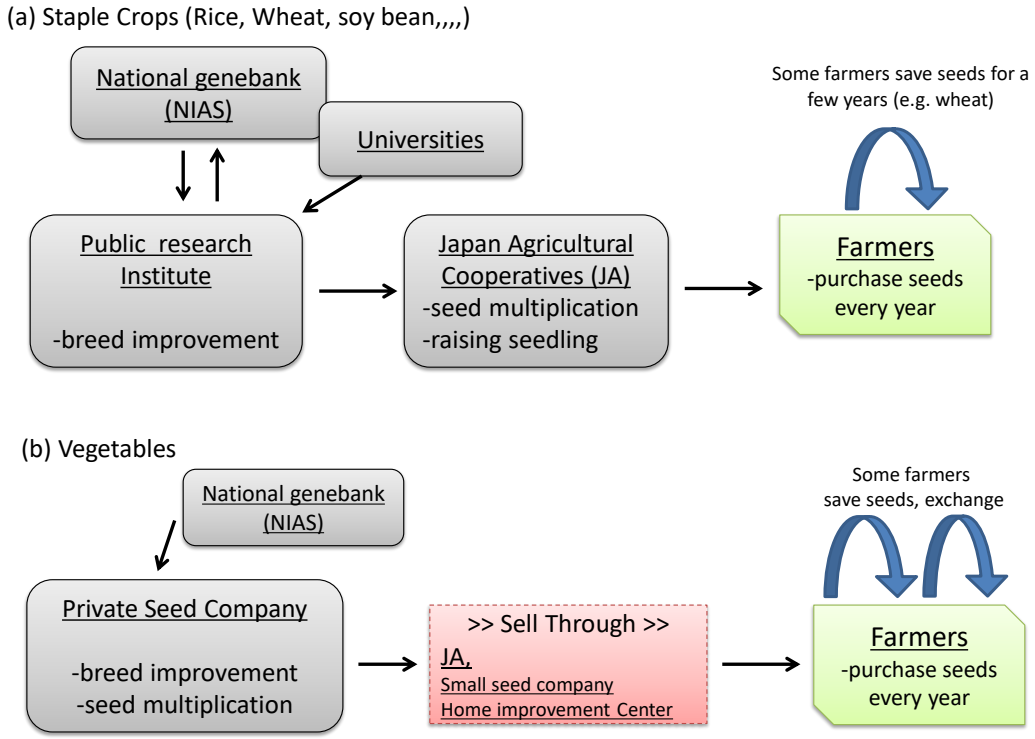
Branded vegetables	Definition	Number of items	Certification organization	Comment
Edo Traditional Vegetables (Edo vegetable)	Traditional vegetables cultivated from the Edo period and vegetables that emerged between the Meiji and mid-Showa periods (1955 to 1964) through horticultural improvements	12	Edo Tokyo Vegetable Promotion Council	The Edo Tokyo brand consists of "Edo traditional" and Tokyo local vegetables
Kyoto Traditional Vegetables	Introduced before the Meiji Period and produced in the Kyoto Prefecture	40 (including extinct items)	Agriculture, Forestry and Fisheries Department, Kyoto Prefectural Government	27 items, including Kyo-yasai, were certified as Kyo brand products
Kaga Vegetables	Cultivated before 1945 and still in production today, mainly in Kanazawa	15	Kanazawa City Branding Association of Agricultural Products	
Yamato Traditional Vegetables	Items documented to have been produced before World War II with a distinctive taste, flavour, and morphology, derived from a unique cultivation style based on local history and culture	18	Agriculture, Forestry and Fisheries Department, Nara Prefectural Government	Yamato vegetables consist of "Yamato traditional vegetables" and "Yamato *kodawari* vegetables"
Noto Traditional Vegetables	Vegetables with distinctive features, cultivated and used in the traditional dietary culture of the Noto region; they were generally cultivated for more than 30 years and developed by a farmers' group	6	Noto Vegetable Promotion Council (office hosted by Ishikawa Prefectural Government)	Noto vegetables consist of "Noto traditional vegetables" and "Noto specialty vegetables (7 items)"

We shall now discuss the present seed system used in Japan. In 1952, during a period of post-war food shortage, the 'Main Crop Seeds Act' was established, to allow the national government to responsibly and stably supply seeds of key grains. This act concerned seeds of rice, wheat, barley, soybeans, and other staple food commodities that were important in Japan. Meanwhile, laws regulating seeds of vegetables and other commodities were based on the Plant Variety Protection and Seed Act. The Plant Variety Protection and Seed Act aimed to protect the 'plant breeders' rights', as per the UPOV (1982/1998). Most seeds, excluding the above-mentioned seeds of rice, wheat, barley, and soybean, were obtained on-farm by farmers or supplied by private seed companies. The improvement of vegetable varieties in the private sector has enabled the supply of varieties, rapidly reflecting the needs of farmers and the market. Meanwhile, portions of local varieties that farmers stopped cultivating have been merely preserved in gene banks. Private seed companies also stock up on important 'farmers' varieties' as 'business resources' or 'breed improvement resources'. However, it is likely that many of these are thrown away, to reduce maintenance costs.

Seed governance in Japan (Figure 1) depends on the crop type (staple crops or vegetables). Farmers purchase seeds of staple crops to be grown (e.g., rice, wheat, soybean) from Japan Agricultural Cooperatives (JA) every year. These seeds are improved by public research institutes at the prefectural level, and breeding lines used for developing these varieties are preserved in prefectural research institutes, national gene bank, or in national universities. Thus, for staple crops, the government (mostly Prefectures) supports seed saving activities and maintains or develops local varieties for farmers; this serves as a form of subsidy.

For vegetables, farmers either buy seeds from merchants (mostly F_1) or produce their own seeds through seed saving activities. Seeds of many vegetables have been improved and supplied by private seed companies. Though SAKATA and TAKII are the two largest seed companies in Japan, several local seed companies deal with specific vegetables. Farmers and home gardeners buy these seeds at local seed shops or from Japan Agricultural Cooperatives (JA), and few farmers save seeds, because this is a labour-intensive activity. Products from saved seeds (open-pollinated or local varieties) are not as highly priced as seeds of improved varieties; therefore, farmers have little motivation to grow the former type, as a result of market-based distribution. This situation arose after the 1970s, due to the support of the government for the large-scale production and mass distribution of improved vegetable varieties.

Figure 1. Characteristics of seed governance in Japan



(4) Determining the status of national/regional on-farm seed saving activities and the role of the present study

The main challenges for the conservation of local varieties are to maintain biodiversity and to continue cultivation according to traditional knowledge (Andersen, 2008). Farmer contributions are essential for maintaining traditional and local knowledge regarding the cultivation of specific varieties. Therefore, understanding on-farm cultivation techniques helps identifying local varieties and how many farmers rely on seed-collecting activities. Based on the seed saving activities carried out in Canada, Phillips (2013) identified their importance in various fields, including gene bank diversity and intellectual property rights, among others. In Meso-American countries, Almekinders et al. (1994) verified that 75–80% and 60–80% of all seed lots in maize and beans, respectively, were saved by farmers. In Ethiopia, approximately 80–90% of farmers use their own saved seeds or seeds obtained locally (Assefa et al., 2013). In the United States, the percentage of soybean seeds saved by farmers decreased from a peak of 63% in 1960 to 33% in 1991, and declined to 10% by 2001 (Mascarenhas and Busch, 2006). However, quantitatively determining on-farm seed saving and informal seed conservation is considered difficult (Hisano, 2012). In developed countries, few quantitative investigations have considered the importance of farmer-saved seeds in staple crops and vegetables, although surveys on seed growing might contribute to domestic and international discussions on farmers' rights and on-farm seed saving.

Here, we provide a detailed, quantitative analysis of seed production by farmers, self-sufficient producers, and individuals managing small vegetable gardens or home gardens, at the regional scale, in Japan. Because on-farm seed conservation in industrialized countries is more difficult than in developing countries, analysing these practices in detail in developing countries,

particularly East Asian countries, is important. In East Asia, grain (rice in particular) is the main food and large populations are supported by it. Therefore, analysis of seed saving activities in Japan provides a unique opportunity to gain insight on sustainable agricultural systems in East Asia.

In the present paper, we analysed the relationship between products and eating habits in the context of seed growing and product cultivation, investigated the prevalence of home seed-saving, and identified the types of vegetables cultivated by local inhabitants, aiming to identify currently cultivated local varieties, varieties that are no longer cultivated, and the factors that affect the cultivation of local varieties.

Determining how many local varieties still exist in each region is therefore necessary to develop strategies for sustainable agriculture and for the conservation of agricultural biological diversity. In this scenario, it is meaningful, if not critical, to analyse the extent of seed saving activities in the local context, and to further examine the relationship between seed saving activities and local varieties.

Pottinger (2017) investigated seed saving activities in the UK and suggested that 'quiet activism' by seed savers contributes to conserving biodiversity and to challenge the corporate control of food and seed systems. However, small farmers worldwide have multiple purposes for choosing their crops, including consumption or cultural purposes (Almekinders et al., 1994). Brush (1991) reported that farmers maintain local varieties next to the improved varieties for home consumption even if local varieties are not profitable. Hence, the purpose of continuously cultivating such crops was surveyed (Challenge 1). Local varieties tend to be cultivated in marginal, risk-prone habitats and ethnological niches (Almekinders et al., 1994). Hence, the geographical characteristics of local varieties and seed saving activities were evaluated (Challenge 2). Barthel et al. (2013) suggested that bio-cultural refugia play an important role in storing, reviving, and transmitting memory of agricultural biodiversity and ecosystem services, and are often composed of small supporting systems. As shown by Jussaume (1990), the Japanese case showed that part-time farmers played important roles in the agricultural industry. Hence, our study focused on full-time farmers, part-time farmers, and non-commercial farm households (home gardeners), and evaluated the relationship between these types of farmers and seed saving activities in Japan (Challenge 3).

To identify the characteristics of Japanese on-farm seed conservation, the following five hypotheses were set based on Challenges 1 to 3: (1) Continuous crop cultivation by local residents is mainly for self-consumption and not for product sale at market prices; (2) Home seed saving activities differ between land types (city, plain, mountain, and seaside) and seed saving activities are more common in mountain areas than in relatively flat areas; (3) Farmers who grow many plants save more seeds because of the cost of purchasing seeds; (4) Plants with relatively high rates of on-farm seed saving are now cultivated to a lesser extent than in the past, whereas plants with low rates of on-farm seed saving are now cultivated to a greater extent than in the past; and (5) Because seed saving is a labour intensive activity, home gardeners are more likely to save seedlings than full-time farmers. Based on the results, implications for managing local seed systems, food sovereignty, and agricultural governance are discussed.

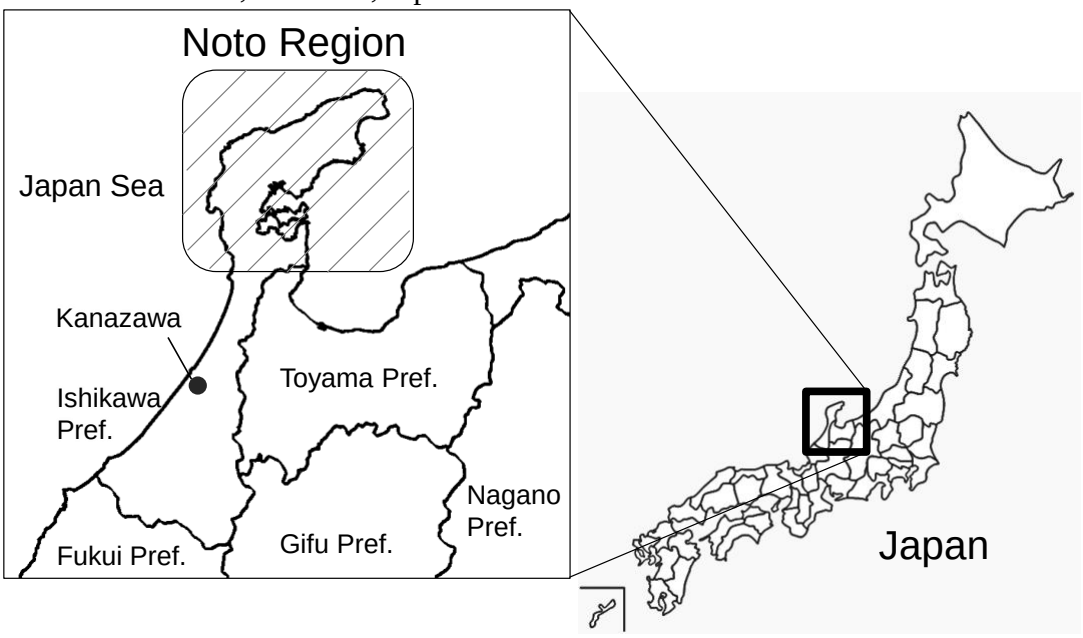
Research Area and Methods

The surveyed region: Noto Peninsula, Ishikawa, Japan

We conducted a questionnaire survey in the Noto Peninsula, Ishikawa Prefecture, Japan (Figure 2). Ishikawa Prefecture is located in the Hokuriku region, northeast of Kyoto. The northern region of Ishikawa Prefecture, where Noto Peninsula is located, is called the Noto Region. In this region, the "Satoyama-satoumi of Noto" is recognized as a historical lifestyle based on traditional agriculture (including agricultural systems and seed saving activities), forestry, and fishing, and was one of the first areas registered as a Globally Important Agricultural Heritage System (GIAHS) by the Food and Agriculture Organization (FAO) in 2011 (Qiu et al., 2014). The traditional festival *Aeno-koto* occurring in the Noto Region also helps preserving Japanese traditional culture and lifestyle. However, few field research studies have considered seed circulation and how its continuity affects food production. The "seed saving activities" referred in the present study imply activities conducted on farms by farmers for self-consumption, and not necessarily the urban social movement that the expression might suggest.

In the Noto Region, farmers cultivate crops, including rice and vegetables, on a relatively small scale. In 1980, 62,098 households were engaged in farming (fulltime = 2,839; part-time = 59,259; home gardener = no data), whereas in 2010 only 26,411 households participated in farming (fulltime = 3,555; part-time = 13,581; home gardener = 9,275). The decrease in the number of total farmers over these 30 years was mostly affected by a decline in the number of part-time farmers.

Figure 2. Location of Noto, Ishikawa, Japan



The government of Ishikawa Prefecture certified six local varieties as "Noto traditional vegetables" to preserve them in Noto Region (Table 3), and these varieties are listed in the cultural heritage of Noto GIAHS. Some of these varieties have been extensively cultivated by farmers. For example, "Nakajima-na" (*Brassica* sp.) have been cultivated and processed to pickles with the support of JA. On the other hand, few farmers grow some local varieties, and these are cultivated

on small scale, mainly for self-consumption, which increases their risk of extinction. Furthermore, the prefectural government does not subsidize farmers preserving these varieties in Noto.

The civil society and NGOs tend to play less important roles in seed saving activities in Noto, and in Japan in general, than in European contexts. Although some NGOs are engaged in seed saving at local, prefectural, and national levels, their actions are not always connected with that of local farmers (Tomiyoshi and Nishikawa, 2012).

Because there are no large cities with many consumers near Noto Region, farming products from this area are not sold for high prices. For this reason, some farmers have switched to organic agriculture to grow value-added products. Agricultural knowledge is relatively well preserved in this region in comparison to other sites in Japan. Naturally, seed saving activities are expected to be continued by many farmers. Therefore, we surveyed this region to determine the state of seed conservation activities in Japan. The Noto GIAHS site includes four cities (Nanao, Wajima, Suzu, and Hakui) and five towns (Shika, Hodatsushimizu, Nakanoto, Anamizu, and Noto), and all were included in the survey.

Questionnaire

We mailed 7,068 questionnaires to randomly sampled residents in the four cities (Nanao: 890, Wajima: 890, Suzu: 881, and Hakui: 890) and five towns (Shika: 400, Hodatsushimizu: 500, Nakanoto: 840, Anamizu: 887, and Noto: 890) of Noto Peninsula between October 1 and October 8, 2013 (see also Hashimoto et al., 2014). The questionnaires were sent to randomly sampled residents via the administrative office and resident organizations. The household or communities questioned were selected to cover all areas in the city or town. The response deadline was October 24, 2013. We received 1,662 valid responses, representing a 23.5% return rate. Respondent demographics are shown in Table 4. The survey questions addressed the following topics: (1) changes in the types of crops cultivated in the region over the last 30 years; (2) the diversity of cultivated plants and seed saving activity; and (3) individual occupation, the type of land they inhabit, and seed saving activity. In the present study, the term “residents” refers to commercial farmers, part-time farmers, home gardeners, and all other occupations (i.e., to all people in this region). The paper published by Bellon (2004) was used as reference, to create several questions regarding crop cultivation.

Table 4. Profiles of interviewees (n = 1,662).

(a) Sex		(c) Residential area		(d) Place of residence	
Male	62.5%	City	21.2%	Hakui city	13.6%
Female	35.7%	Plain	37.2%	Houdatsushimizu Town	12.9%
N.A.	1.9%	Mountain	18.4%	Shika town	2.5%
(b) Age		Seaside	19.4%	Nanao city	17.1%
-49	28.8%	N.A.	3.5%	Nakanoto town	20.2%
50-59	22.1%	(e) Proportion of farmer types*		Wajima city	12.9%
60-69	30.7%	Full-time farmers	7.6%	Suzu city	9.2%
70-	16.7%	Part-time farmers	26.4%	Anamizu town	4.8%
N.A.	1.7%	Home gardeners	38.1%	Noto town	5.1%
				N.A.	1.6%

* The percentage of "full-time farmers" was determined from answers to the question regarding occupation (single answer), while those for "part time farmers" and "home gardeners" were obtained from answers to the question regarding how respondents were engaged in agricultural activities in their daily life (multiple answer).

Analysis of the survey data

The data were analysed using the statistical package R 3.1.0 (https://www.r-project.org/), and are generally represented as ratios of the responses to the survey questions (SA: single answers; and MA: multiple answers).

The characteristics of seed saving activities by residents in four areas (city, plain, mountain, and seaside) were analysed using F-tests. The relationship between the methods used for obtaining seeds and the number of crops cultivated by the respondents were analysed using chi-squared tests. Non-hierarchical cluster analysis (k-means clustering) was conducted to determine the relationships between seed saving activities and changes in crop cultivation between the present and 30 years ago (Figure 3) that were reported by the respondents. We defined "changes in crop cultivation (%)" as: [(number of crops and vegetables currently cultivated) - (number of crops and

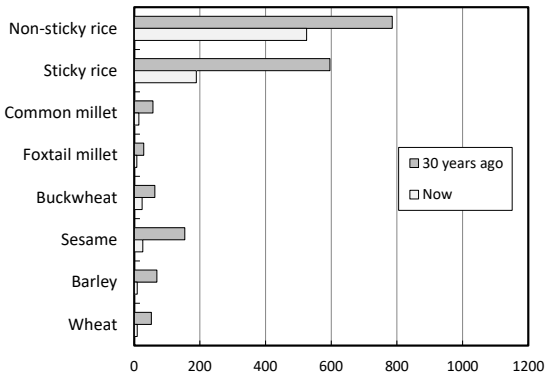
vegetables cultivated 30 years ago)] / (number of crops and vegetables cultivated 30 years ago) * 100

Results

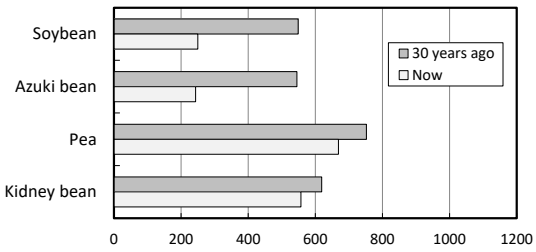
Changes in crop cultivation and factors affecting these changes

Figure 3 shows the number of respondents currently cultivating each crop/vegetable compared to the number that cultivated each crop/vegetable 30 years ago. Many people stopped cultivating crops such as rice, sticky rice, soybean, and azuki bean, whereas some people begun to cultivate potato, Welsh onion, cucumber, and eggplant. Grains, such as common millet, foxtail millet, buckwheat, sesame, barley, and wheat, were cultivated relatively infrequently 30 years ago, and their cultivation rate decreased over the last 30 years (Figure 3a). Only approximately 20 individuals reported growing millet, buckwheat, or sesame. In addition, the number of individuals growing non-sticky and sticky rice decreased over the past 30 years, possibly due to the decreased consumption of rice cakes or availability of rice cakes at supermarkets. The cultivation of all types of beans also decreased (Figure 3b). The cultivation of peas and string beans decreased only slightly, whereas soybean and azuki bean cultivation decreased by more than 50%. Potato was the most frequently grown tuber, followed by sweet potato and taro (Figure 3c). Compared to 30 years ago, the cultivation of sweet potato and taro decreased, whereas that of potatoes increased slightly. Finally, burdock root, turnip, and carrot were less commonly cultivated at the time of the survey than they were 30 years ago, whereas Welsh onion and radish were more commonly cultivated (Figure 3d). Other vegetables not classified into these categories, such as cucumber, eggplant, Chinese cabbage, and pumpkin, are still cultivated by many farmers (Figure 3e). Cucumber, eggplant, *komatsuna* (Japanese mustard spinach), and Japanese ginger were cultivated at increased rates compared to those 30 years ago.

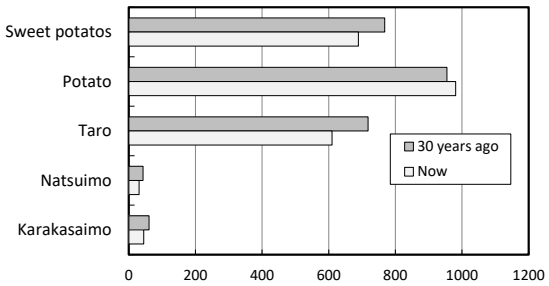
Figure 3. Crops and vegetables cultivated at present and 30 years ago (MA, multiple answers)



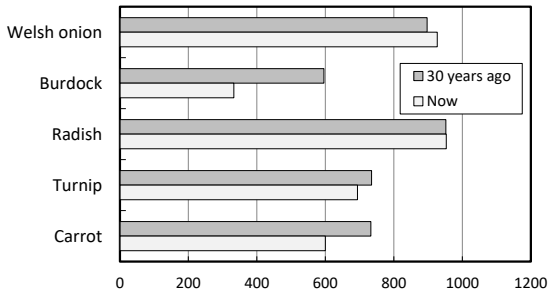
(a) Grains



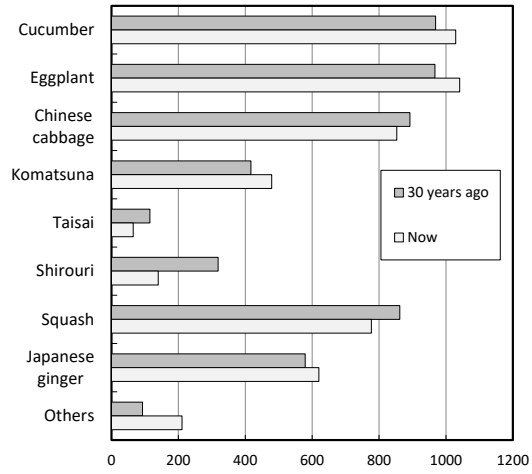
(b) Pulses (Beans)



(c) Tubers



(d) Roots



(e) Others

The main reasons for continuing crop cultivation included preference for homegrown food, food safety, family concerns, and better taste, but not good market price (Table 5). This implies that many people grow plants for self-consumption but not for market sale, which supports hypothesis 1. Contrary to general expectations, economic incentive played an insignificant role; the percentages attributed to non-economic reasons were higher for “seed saving people” than for “no seed saving people.” Because people who saved seeds tended to cultivate more crops, seed saving activities and the number of cultivated plants seemed to have a positive co-relation (Table 4a).

Respondents indicated that, in addition to problems related to cultivation practices and production costs, decreases in family size and changes in lifestyle (e.g., purchasing vegetables at grocery stores) were the major factors contributing to the cessation of cultivation (Table 4b). Again, low market price was rarely a reason for discontinuing cultivation. These data are consistent with the fact that the majority of respondents were part-time farmers or home gardeners. We found no correlations between individual profiles (residence time, sex, residential area) and reasons to continue or abandon production activities.

Table 5. Reasons for continuing or stopping the cultivation of crops (MA).

(a) Reasons to continue cultivation (n = 1,089)

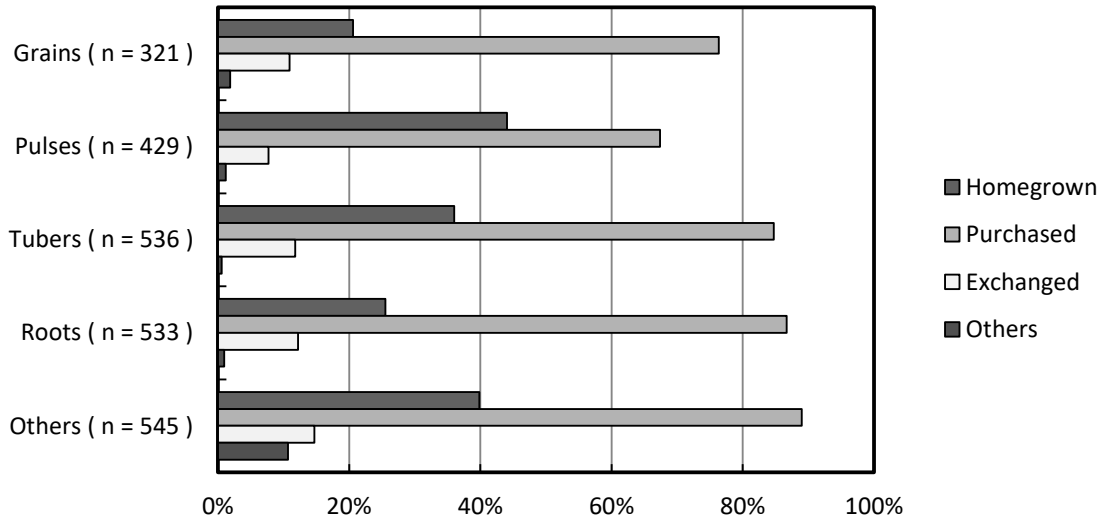
	Total		Cross-analysis 1		Cross-analysis 2	
			Number of currently cultivated plants		Seed saving activity	
	n=1089	%	<10 (n=716)	>11 (n=946)	None (n=1,311)	>1 (n=351)
Prefer homemade food	872	80.1%	37.6%	63.7%	43.8%	84.9%
Easy to cultivate	337	30.9%	17.3%	22.5%	16.9%	32.8%
Good market price	11	1.0%	0.4%	0.8%	0.5%	1.4%
Tasty	517	47.5%	16.8%	42.0%	23.8%	58.4%
For family	578	53.1%	22.3%	44.2%	27.4%	62.4%
For relatives	177	16.3%	5.2%	14.8%	7.7%	21.7%
Food safety	660	60.6%	23.7%	51.8%	31.7%	69.5%
Local traditions	66	6.1%	2.2%	5.3%	3.1%	7.4%

(b) Reasons to stop cultivation (n = 929)

	Total		Cross-analysis 1		Cross-analysis 2	
			Number of currently cultivated plants		Seed saving activity	
	n=929	%	<10 (n=716)	>11 (n=946)	None (n=1,311)	>1 (n=351)
Huge labour requirements	538	57.9%	28.4%	35.4%	27.4%	51.0%
Difficult to cultivate	340	36.6%	13.8%	25.5%	17.0%	33.3%
Low market price	37	4.0%	1.4%	2.9%	1.9%	3.4%
Not tasty	18	1.9%	0.8%	1.3%	0.7%	2.6%
Smaller households	352	37.9%	18.7%	23.0%	18.2%	32.2%
Relatives/friends moved away	40	4.3%	2.1%	2.6%	2.1%	3.4%

May be purchased in nearby stores	398	42.8%	23.7%	24.1%	21.5%	33.0%

Figure 4. Methods used by local residents to obtain seeds for cultivating crops and vegetables



Current seed saving activities of local residents in Noto

We analysed how respondents obtained seeds. Respondents who obtained seeds using a given method (homegrown, purchased, exchange, or other) for at least one crop in each category (grains, pulses, etc.) were counted (Figure 4). As some respondents used seeds from different origins, the sum of the percentages for each category might exceed 100% (Tables 6, 7, and 8). The majority of individuals purchased seeds. Seed saving was most common for beans, tubers, and other vegetables (about 40%), whereas seed saving for grains and roots was about 20%. Interestingly, 10–15% of individuals reported participating in seed exchanges (Figure 4).

Some respondents practiced on-farm seed saving for rice (non-sticky, 15%; sticky, 19%) and wheat, but nearly 40% reported on-farm seed saving for common millet, foxtail millet, sesame, and barley (Table 6a). This is probably because rice and wheat are designated by the government as central crops and their seeds are managed under public authority (Hisano, 1999). Although the majority of farmers likely purchased rice and wheat seeds through an agricultural cooperative association, not all farmers purchased rice seeds.

The majority of farmers who grew peas and kidney beans (60%) purchased seeds. However, in the case of azuki bean and soybean, the prevalence of on-farm seed saving was higher and slightly higher, respectively, than that of seed purchase (Table 6b). Some local residents continued to cultivate specific crops using on-farm produced seeds, suggesting that many local varieties of soybean and azuki bean had been maintained and conserved in Noto Region.

The majority of respondents who grew tubers reported that they purchased seeds, particularly seeds for potato and sweet potato (Table 6c). Potato and taro were further classified according to their local names (*natsuimo* and *karakasaimo*, respectively). For these species, greater

ratios of respondents reported on-farm seed saving because fewer individuals cultivated these varieties.

The majority of root vegetables were cultivated from purchased seeds (Table 6d). More than 80% of respondents who grew burdock, radishes, turnips, and carrots reported purchasing seeds for these vegetables. With the exception of Welsh onion, on-farm seed saving rates for root vegetables were generally lower than 20%.

More than 80% of respondents who grew cucumber, eggplant, Chinese cabbage, *komatsuna*, and *Taisai* purchased seeds (Table 6e). For *shirouri* (melon, *Cucumis melo*) and squash, the percentages of on-farm seed saving were higher (greater than 20%) than that of other vegetables in this category. Japanese ginger was unique, as more than half of the respondents who grew this species obtained seeds by seed saving, although more than 20% used other methods for obtaining seeds. Many respondents indicated that Japanese ginger grew wild on their properties.

In total, 351 respondents (21.1%) saved seeds from more than one plant. This implies that about one fifth of Noto residents engage in seed saving activities, regardless of their occupation, a result that is of great importance for seed management research worldwide.

Table 6. Methods through which local residents could obtain seeds for cultivating crops and vegetables (MA)

	n	Homegrown	Purchased	Exchanged	Others
(a) Grains					
Non-sticky rice	290	14.5%	79.0%	7.6%	1.7%
Sticky rice	101	18.8%	67.3%	12.9%	2.0%
Common millet	13	46.2%	38.5%	23.1%	0.0%
Foxtail millet	6	50.0%	33.3%	33.3%	0.0%
Buckwheat	18	38.9%	50.0%	11.1%	0.0%
Sesame	15	46.7%	53.3%	0.0%	0.0%
Barley	6	50.0%	50.0%	0.0%	0.0%
Wheat	10	20.0%	70.0%	10.0%	0.0%
(b) Pulses (Beans)					
Soybean	148	50.0%	48.6%	4.7%	0.7%
Azuki bean	151	60.3%	35.1%	7.3%	0.7%
Pea	333	35.1%	62.2%	3.6%	1.2%
Kidney bean	256	33.2%	61.3%	6.6%	0.8%

(c) Tubers					
Sweet potato	358	11.7%	84.9%	5.9%	0.6%
Potato	497	24.1%	76.9%	3.4%	0.2%
Taro	316	38.3%	55.1%	12.3%	0.3%
Natsuimo	12	41.7%	50.0%	8.3%	0.0%
Karakasaimo	18	44.4%	50.0%	16.7%	0.0%
(d) Roots					
Welsh onion	463	25.3%	67.8%	10.4%	0.2%
Burdock	194	12.4%	86.6%	3.6%	0.0%
Radish	472	12.9%	85.2%	3.4%	0.6%
Turnip	340	13.2%	84.1%	3.8%	0.6%
Carrot	285	12.6%	86.7%	2.8%	1.1%
(e) Other vegetables					
Cucumber	480	9.0%	88.5%	5.2%	0.2%
Eggplant	486	9.1%	88.1%	6.2%	0.2%
Chinese cabbage	397	11.6%	84.4%	7.3%	0.5%
Komatsuna	215	14.4%	83.3%	2.3%	0.9%
Taisai	30	6.7%	90.0%	3.3%	0.0%
Shirouri	62	24.2%	69.4%	6.5%	0.0%
Squash	358	27.4%	65.4%	9.8%	1.1%
Japanese ginger	231	52.4%	21.6%	5.2%	23.4%
Others	109	30.3%	78.0%	13.8%	0.9%

Relationships between seed saving activities and other characteristics

The relationships between the methods used to obtain seeds and the land type in which respondents resided are shown in Table 7. Over 90% of respondents purchased at least some seeds, regardless of their residential area, indicating that the industrial seed supply system is prevalent in all Noto areas. The rate of on-farm seed saving was higher in mountain areas (65.2%) and plains (58.4%) than in urban and coastal areas. Significant differences were observed between urban

areas and plains, urban and mountain areas, urban and coastal areas, plains and coastal areas, and mountain and coastal areas (F-test). However, there was no significant difference in on-farm seed saving rates between plains and mountain areas. Therefore, hypothesis 2 was rejected. Some researchers have suggested that local varieties are more preserved in mountain areas than in plains. The lack of significant differences between these areas found in the present study might be because Noto mountains are not very high.

Table 7. Seed-saving activities in different locations (MA)

	N	Homegrown	Purchased	Exchanged	Others
City	72	45.8%	91.7%	30.6%	5.6%
Plain	281	58.4%	92.9%	27%	13.2%
Mountain	141	65.2%	92.9%	31.9%	8.5%
Seaside	103	51.5%	93.2%	32%	11.7%
Total	610	57.5%	93%	29.5%	10.7%

Chi-squared tests revealed that the distribution of seeds obtained by each method, i.e., seed saving, purchase, and seed exchange, differed significantly according to the number of crops cultivated (10 or fewer versus 11 or more; about half of the samples could be divided into these two categories; Table 8). Growers who cultivated 11 or more crops tended to practice on-farm seed saving at a higher rate than those who cultivated fewer crops. This supports hypothesis 3. However, growers who cultivated a lower number of crops obtained seeds from other growers at a higher rate than those who cultivated large numbers of crops.

Table 8. Seed-saving activities according to the number of cultivated plants (MA; n = 612; Chi-squared = 15.44, p-value = 0.0015)

	n	Homegrown	Purchased	Exchanged	Others
Ten items or less	223	31.8%	91.0%	33.2%	4.5%
Eleven items or more	389	72.0%	94.1%	27.2%	14.1%

We also examined cultivated plants and seed saving activities according to the type of farmer (Table 9). First, 34.6% of full-time farmers saved the seeds of more than one crop. In the case of part-time farmers and home gardeners, the rates of seed saving were 33.5% and 35.0%, respectively. Thus, the percentage of saved seeds was not very different among farmer types in

Noto. In other words, about 1/3 of farmers engage in seed saving thereby rejecting hypothesis 5 (home gardener saves more seeds). However, the percentage of both seed savers and non seed savers cultivating more than 11 items was higher than that of farmers cultivating less than 10 items (Table 9a,b). This trend was more pronounced for seed saving farmers (Table 9a), as these tended to cultivate more plants.

Table 9. Seed-saving activities according to farmer type and number of cultivated plants

Farmer type	(a) Saving seeds (at least one)			(b) Not saving seeds (zero)		
	n	Less than 10 items	More than 11 items	n	Less than 10 items	More than 11 items
Full-time farmers	44	11.4%	88.6%	83	30.1%	69.9%
Part-time farmers	147	13.6%	86.4%	292	32.5%	67.5%
Home gardeners	222	16.7%	83.3%	412	43.4%	56.6%

Relationships between methods for obtaining seeds and changes in crop cultivation

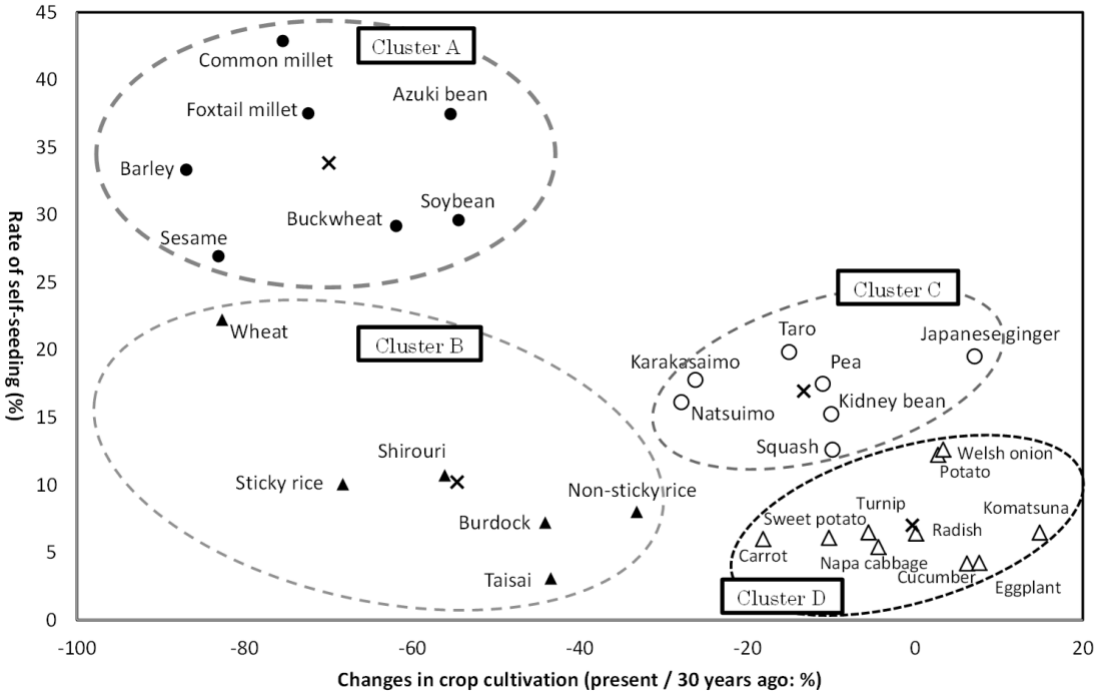
The results of non-hierarchical cluster analysis (k-means clustering) are shown in Figure 5. All crops and vegetables were grouped into four clusters. Cluster A included vegetables with high rates of on-farm seed saving for which cultivation had decreased over time. Minor crops, azuki bean, and soybean were included in this cluster. Cluster B included crops with decreased cultivation rates and relatively low rates of on-farm seed saving, such as rice (non-sticky and sticky), burdock, and *shirouri*. The vegetables in cluster C included those with relatively high rates of home seed saving for which cultivation had not significantly decreased (or increased). The local varieties of vegetables included in cluster C are thought to be the best conserved in the Noto area. Finally, cluster D included vegetables with low home seed-saving rates for which cultivation had not decreased, such as *komatsuna*, radish, Chinese cabbage, and cucumber. In cluster D, local varieties had been replaced with improved varieties, suggesting that it would be difficult to conserve the local varieties of these vegetables by on-farm seed saving. *Natsuimo, karakasaimo,* and taro were clustered in group C. However, potato was clustered in group D. This indicates that seed-saving activities were most common for vegetables with local (or old) names.

Clusters A and D provide some support for hypothesis 4. People tend to rely on market-based seeds rather than their own seeds. However, the rate of respondents growing soybean might be smaller because soybean is still one of the most important plants in Japan.

In the 1990's, both the public and private sector started to conserve local varieties as "traditional vegetables" by certifying them as genetically or culturally important varieties. Many varieties of these "traditional vegetables" were included in clusters C and D. This indicates that improved varieties have been rapidly replaced by local varieties.

Figure 5. Relationship between changes in crop cultivation and on-farm seed saving activities.

*Cluster analysis (k-means clustering) grouped crops into four clusters; "x" indicates the centre of each cluster.



Discussion

The importance of on-farm activities has not been completely recognized by farmers, hobby farmers, or NPOs. In this study, we identified trends for the conservation of varietal diversity in Japan, mainly for part-time farmers and home gardeners. The majority of local residents produced crops in home gardens and we provided quantitative data describing farmers' contributions to the conservation of crop diversity. Therefore, the results of this study provide a basis for understanding the dissemination of local varieties and farmers' knowledge of specific local practices in the Noto Region of Japan.

Quantitatively analysing worldwide on-farm seed saving and informal seed conservation is considered difficult (Hisano, 2012). The international community has recognized the need for preservation of local varieties, emphasizing the role of farmers in protecting genetic resources and diversity. Nishikawa (2005) suggested that cooperation at the international, national, and local levels is required to encourage the preservation of genetic resources and sustainable utilization. These issues have exposed challenges regarding farmers' rights and food sovereignty, which have recently been discussed by the United Nations. The international organization La Via Campesina has advocated for "food sovereignty" (Wittman, 2010; Mashima, 2011), and similar groups have argued for "seed sovereignty" in protest against multinational seed companies (Kloppenburg, 2010(a);(b)). However, we found that most farmers who grew local varieties and participated in seed saving did so not to preserve local varieties but to produce crops that tasted good, had high

nutritional value, and met their general food needs. Educating these residents regarding conservation is not enough to ensure preservation of local varieties. A better alternative would be to establish small markets and farmers' restaurants in which people could enjoy local food with vegetables of local varieties, to allow local residents to build pride in the vegetables grown in their areas. For example, Tsuruoka City in Yamagata Prefecture has established the Tsuruoka Creative City of Gastronomy Promotion Council, which works in collaboration with organizations related to seed saving and aims for the city to join the UNESCO Creative Cities Network.

The Japan Organic Agriculture Association (JOAA, 2010) conducted a study on on-farm seed saving by organic farmers in Japan and found that 58.7% of organic farmers are involved in on-farm seed saving: 66.9% of these produce tuber and root crops and 62.3% produce beans. The JOAA study also reported that organic farmers believed that on-farm seed saving promoted the circulation of organic farming and seeds (46.3%), conserved varieties that are fit for farming and can be inherited (46.3%), reduced seed costs (46.3%), and allowed local and traditional varieties to be inherited (42.6%). These findings were contradictory to those of our study, in which farmers were not concerned with the inheritance or preservation of traditional or local varieties. This discrepancy might be due to the different respondent groups and scales used in both studies. Whereas our goal was to survey a cross-section of all local residents, including farmers, respondents to the JOAA survey were all organic farmers who were members of the organization. These members were highly conscious of on-farm seed saving; however, they represented a very small proportion of people engaged in agriculture in Japan. Organic agricultural products comprise less than 0.5% of the total Japanese agricultural output. Further investigations are required to determine the motivations for on-farm seed saving in different regions of Japan.

Soybean is a major component of Japanese cuisine and it is used as the main ingredient in many sauces, as well as in miso and tofu (Moore, 2013). Azuki beans are also frequently used for Japanese sweets, such as sweet bean paste (*anko*). The remarkable decrease in the cultivation of these crops in the Noto Region reported in the present study might be due to changes in regional food culture. Some local residents continue to cultivate specific crops, such as soybean and azuki bean, through on-farm seed saving. This situation implies that many local varieties of the crops within "cluster A" may be maintained and conserved to a greater degree in this region than in other Japanese regions. Moreover, cultivation of Sawano burdock, which has been certified as a Noto traditional vegetable, reportedly decreased over the past 30 years. The cultivation of this root is time-consuming, and it is difficult to harvest. The decrease in the cultivation of Sawano burdock in the Noto Region might therefore be due to the inability of the aging population to continue its cultivation. This situation suggests that the conservation of the genetic diversity of some vegetables in cluster B, including burdock, is more difficult than that of other vegetables. In contrast, the cultivation of Welsh onion and radish, which are relatively easy to cultivate and harvest, reportedly increased over the last 30 years. Similarly, the high percentage of on-farm seed saving associated with Japanese ginger might be due to its ease of cultivation, as this crop is native to Japan and continues to grow wild on some properties.

We found that 7.7–14.7% of respondents exchange seeds with other farmers (Figure 4). This confirms that seed exchange still prevails in the Noto Region, although this custom was not limited to local varieties and included on-farm seed saving from plants grown using purchased seeds or exchanges of surplus seeds at shops, and did not fit the conventional definition of on-farm seed saving from local varieties. Maintenance of local crop varieties and promotion of crop genetic diversity in the region requires the continuation of seed-sharing customs. We found that exchanged

seeds were used primarily for cultivation of crops intended for personal consumption, and not for sale. The results of this study highlight both domestic and international concerns regarding farmers' rights and on-farm seed saving in a local situation. Pottinger (2017) suggested that 'quiet activism' by seed savers contributes for conserving biodiversity and to challenge the corporate control of food and seed systems. However, as per the case of Japan, many farmers and home gardeners saved seeds, not via 'quiet activism,' but for food security and need for community sharing. Seed swap by national seed networks are conducted by NGOs or organic farmers, but most farmers are not engaged in these collective actions by social activists. Thus, seed management in developed countries (especially in East Asian countries) must take account of home gardeners and farmers with no social activism in mind.

While Gilbert (2013) described the status of seed saving activities at allotment gardens in Britain, the present study shed light on the status of on-farm seed saving activities across an entire region (at the level of multiple municipalities). The concerns expressed in this study may be similar to aspects of 're-peasantization,' discussed by Da Via (2012), in which farmers collect seeds independently, without depending on seed makers. Yet, the 're' of 're-peasantization' does not fit into the present study, as it has focused on customs and regional cultures that have persisted in Japan to date. Our results showed that part-time and non-commercial farm households are the main seed saving actors in Japan. Full-time farmers also saved seeds; however, they are small in number in the rural community of Japan. As a result, seed conservation has been carried out through the practice of on-farm seed saving, rather than through participation in 'exchange networks', and this is in contrast with the characteristics of Europe, which were discussed by Da Via (2012). In addition, the shift to part-time farming in Japan has resulted in the survival of crops cultivated for the purpose of self-sufficiency and culture—not mere agricultural production based on commerce. As mentioned by Gilbert (2013), the deskilling of farmers might have been curbed to a certain extent in Japan, as a result of such purposes.

In Japan, during the 1980s, Takashi Aoba pointed out the value of local crops as 'living cultural assets' and strongly supported activities led mainly by the Faculty of Agriculture of Yamagata University, to collect and conserve local crops in the Yamagata prefecture. Later, a chef of Italian cuisine gained popularity with a style called 'traditional vegetables × Italian', in which local crops of the region were served at an Italian restaurant, attaching new value to local crops. Further, the Tsuruoka city, where the restaurant stood, was designated a 'Creative City of Gastronomy' by UNESCO, leading to 'regional' engagements from the angle of 'value creation,' beyond simply the conservation of local crops. According to Jordan (2007), the value of heirloom tomatoes gained new recognition in cities such as Manhattan in the United States. In Japan, on the other hand, the creation of new values of local crops occurred through establishments such as farmers' restaurants, in regions where they were traditionally cultivated. Of course, there are some fashionable restaurants in Tokyo, in which the chefs use the local varieties of vegetables because these varieties have an attractive, unique shape and taste.

Case studies from Japan showed that many farmers conserved and utilised varietal diversity, while neither pursuing financial benefits within global politico-economic frameworks, nor emphasising their sense of entitlement (i.e. farmers' rights) (Nishikawa, 2019).

The results of our cluster analysis suggest that different conservation strategies should be developed for each group of vegetables. Our study site, the Noto Peninsula, is known for maintaining traditional agricultural practices. We therefore expected on-farm seed collection to be more common in this region than in the entire country. The results obtained here contribute for managing local seed systems, food sovereignty, and agricultural governance. They are also

academically relevant for the global readership, and across East Asia, where depopulation and aging producers are likely to become a major issue. We have demonstrated that seed saving is prerequisite for maintaining local varieties at the prefectural level (at local/regional municipality), which is a large-scale activity conducted in Japan. Thus, future research should focus on the identification of seed saving trends in other regions of Japan. Such studies might also contribute to manage crop genetic diversity worldwide, particularly in developed countries.

Biographical Note

Dr. Mitsuyuki Tomiyoshi is an Associate Professor in faculty of economics, Kurume University, Japan. During his Master's degree, he conducted surveys on the distribution of cultivated and wild varieties of buckwheat, and examined the phylogenetic relationships through DNA sequence comparison. Subsequently, for his doctoral degree, he examined the role of Non-Profit Organizations (NPOs) networks and their activities on agriculture and agricultural communities. Now he is a specialist of searching the seed conservation systems of traditional vegetables in Japan and east Asian countries.

Dr. Yuta Uchiyama is a lecturer at Nagoya University. He earned his Ph.D. at the Graduate School of Chiba University. His major interests are urban-regional planning and geographic information science. After obtaining his doctorate, he started working for the Research Institute for Humanity and Nature, Kanazawa University, and Tohoku University. He was involved in comprehensive studies on urban and rural areas through visualization of ecosystem services. He is currently engaged in evaluating the ecosystem service in Asia Pacific Region and contributed to elaborating the IPBES report (as a contributing author) and Global Environment Outlook 6 for Youth (as a lead author).

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Figure legends

Figure 1. Location of Noto, Ishikawa, Japan

Figure 2. Characteristics of seed governance in Japan

Figure 3. Crops and vegetables cultivated at present and 30 years ago (MA, multiple answers)

Figure 4. Methods used by local residents to obtain seeds for cultivating crops and vegetables

Figure 5. Relationship between changes in crop cultivation and on-farm seed saving *Cluster analysis (k-means clustering) grouped crops into four clusters; “x” indicates the centre of each cluster.