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Local Agricultural Knowledge as Time Manipulation

Paddy Field Farmers after the Great East Japan Earthquake of 2011

This article explores the role of paddy field farmers' local knowledge in the context of adaptation to a post-disaster setting. The Tohoku earthquake and tsunami of 2011 heavily damaged the northeast coastal region and swept away virtually all human spaces, including agricultural fields. Many small-scale farmers abandoned cultivation, and the government instead facilitated large-scale farmers. Those who restarted rice production expanded the cultivated land. I examine this socio-cultural context focusing on the dynamism and complexities of the farmers' local knowledge. The most important aspect in this knowledge can be seen as time manipulation contributing to labor efficiency. Local knowledge has three dimensions: maturation process, environment, and biological response. While the first two of these are oriented to tradition and the collective, the last is rather individualistic and is innovative in nature. Embracing these three types of knowledge in communities has supported agricultural adaptation in the post-disaster context.

keywords: rice farming—indigenous (local) knowledge—ethno-phenology—disaster risk reduction—tsunami

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The purpose of this paper is to uncover the cultural processes underlying local methods of agricultural reconstruction in the Northeast (Tohoku) region of Japan that was ravaged by the great earthquake and tsunami of March 11, 2011. In particular, I examine the effects of the tsunami on local rice fields and how local knowledge is contributing to agricultural reconstruction, focusing on the case of farmers in Miyagi prefecture. I will consider the role of local knowledge in post-disaster reconstruction and discuss how its application has buttressed the resilience of farming communities in these areas of Northeast Japan.

Anthropologists regard natural disasters as events that can expose weaknesses in socio-cultural systems. Their approach seeks out aspects of social process rather than investigating the particulars of an event. Disaster provides a rare opportunity for observing resistance and resilience in society in the face of chaos, and as such it sometimes reveals the essence of social mechanisms in a given community (Hoffman and Oliver-Smith 2002). In the case of the Tohoku earthquake and tsunami, some anthropologists have discussed the roles of cultural continuity in the face of disaster in terms of identity and morals (Gill 2015; Gill, Steger, and Slater 2015, Slater 2015), and festivals and rituals (Kimura 2016; Takizawa 2014), while others focus on resilience and the indigenous knowledge embedded in coastal fishing communities (Wilhelm and Delaney 2015; Ueda and Torigoe 2012). Not being applied anthropology, these are descriptive studies on the socio-cultural processes of the affected region.

Indigenous knowledge has also been discussed in disaster risk reduction research (Marin 2010; Hayashi 2016; Oliver-Smith 2013; Speranza et al., 2010). These studies are not purely academic; they have also been recommended as useful reference works by United Nations agencies and other international organizations. Triggered primarily by the Sumatra-Andaman earthquake and Indian Ocean tsunami of 2004, this area of research furthermore involves interdisciplinary contexts and policy orientations. In the years since that catastrophe, international policy makers and academics have paid increasing attention to indigenous knowledge, such as local oral traditions concerning natural disasters, as a type of media effective in education for risk reduction. The United Nations Office for Disaster Risk Reduction actively advocates awareness of indigenous and local knowledge as an effective tool for disaster risk reduction, both in the pre-disaster (prevention) and post-disaster (recovery) phases. Contemporary ways of thinking might be skeptical of any relation between indigenous knowledge and disaster risk reduction. However, some indigenous knowledge is specifically related to disasters; in addition, this type of knowledge is culture specific. Hence researchers in this field investigate local knowledge related to risk reduction and consider its applicability beyond the culture in which it arose (UNISDR 2008, v–vii).

Some researchers have explored the role of indigenous culture in the context of disaster risk reduction in areas such as housing (Pasupleti 2013). On a different level, in the coastal communities of Iwate there is an oral tradition known as *tsunami tendenko*, which conveys the urgent advice to save yourself, even at the cost of leaving family members, by fleeing to higher ground when a tsunami strikes, thus ensuring the survival of as many as possible (Yamori 2012). The study by Lisa Hiwasaki and others is an impressive work in this area. The authors categorized local and indigenous knowledge related to natural disasters in order to identify knowledge that can be scientifically tested and brought to bear on disaster risk reduction (Hiwasaki et al. 2014). Collecting local and indigenous knowledge associated both with preparedness for and urgent relief following a disaster could be vital for disaster risk reduction research. Compiling this knowledge also provides a nexus for collaboration by anthropologists and policy makers. In disaster science, "indigenous knowledge" generally refers to local or traditional ecological knowledge with no political connotations. But the document issued by the 2015 UN World Conference on Disaster Risk Reduction recommended ensuring "the use of traditional, indigenous and local knowledge and practices" for disaster risk reduction, to "complement scientific knowledge in disaster risk management" (UNISDR 2015, 15).

In this paper I use the term indigenous or local knowledge in relation to disaster risk reduction research, but I reject any dichotomy between science and local indigenous knowledge. Previous anthropological research has criticized the idea of a people "immobilized by their belonging to a place," "groups in remote parts of the world," or "prisoners of their 'mode of thought'" (Appadurai 1988, 37, 39). The indigenous knowledge that concerns me here is collective, centered on a given community related to a particular geographical area, transmitted both by insiders and outsiders, and inclusive of science and technology, with individual differences among communities.

Within those parameters, I explore the nature of local and indigenous knowledge in relation to post-disaster agricultural recovery processes. Needless to say, as persuasively argued in the immense anthropological literature on "invented tradition" (Hobsbawn and Ranger 1992) no indigenous or local knowledge is unchanging. I also analyze the dynamism and complexities of local knowledge and examine how it works in the disaster reconstruction process. That involves closely examining the interaction of local knowledge, post-disaster reconstruction policies, and the related science and technology, and then discussing how this process can lead to greater resilience in farming communities. "Resilience" here means individual or group capacities for dealing with, resisting, and recovering from the effects of natural disasters (Oliver-Smith 2009, 14). Concretely, the core research task of this paper is to uncover the complexities of local agricultural knowledge. Focusing on the case of paddy field farmers in the southern part of Miyagi prefecture, I seek and identify agricultural knowledge related to the post-disaster risk reduction in order to explore its applicability to a wider range of locations.

The tsunami in Yamamoto township

More than 85 percent of deaths in the Tohoku disaster were due to the tsunami (*Nihon keizai shinbun* 2011). The giant tidal waves that swept the coastal regions resulted in a massive death toll. In the immediate wake of the waves, paddy fields were covered with a heavy volume of debris that mounted as a result of sediment accumulation, and that was aggravated by further damage from the tsunami. The farming population dropped precipitously due to a combination of causes: the death toll, loss of agricultural machinery, and damage to farmland. Seven years have passed since the tsunami, during which time the government and local administrations have been working on reconstruction. Most farmland has been restored for possible cultivation, but the farming population has not recovered to anything near pre-tsunami levels. The loss of farmers by death or migration after the disaster is one factor, but another is the aging of the farming population. The Japanese

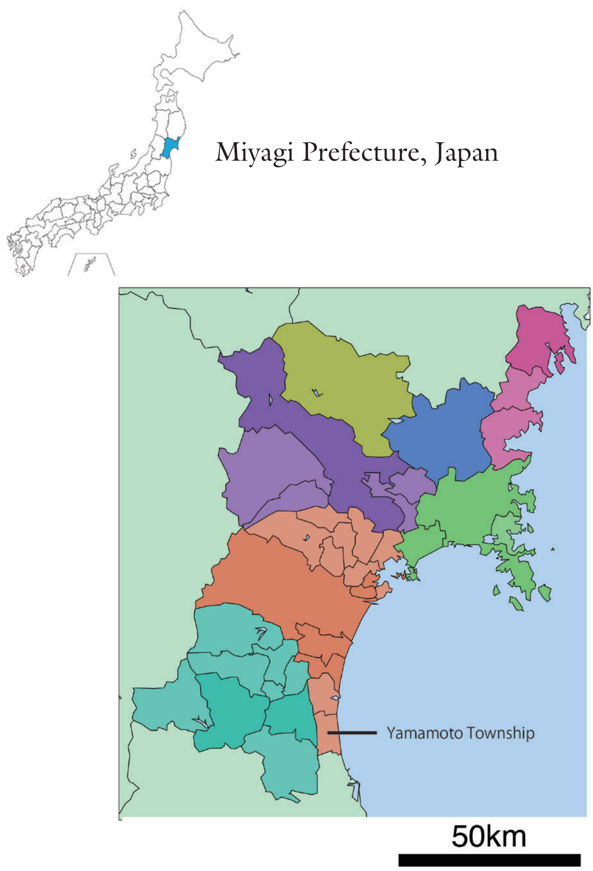

Figure 1: Map of field research. Image by the author.

Yamamoto township before the tsunami, 10 December 2009

Yamamoto township after the tsunami, 6 April 2011

Yamamoto township as of 1 June 2015

Figures 2a, b, & c:
Date of original imagery: 28 November 2016
Location name: Nakahama, Yamamoto-township, Miyagi, Japan
Geographic coordinates: 37.55.87.000 N, 140.54.41.000 E
Eye altitude: 3.36km
Image source(s) and copyright(s): 2016 DigitalGlobe (Google Earth)
Website URL: https://www.google.co.jp/intl/ja/earth/

government has instituted measures to support and aid agricultural organizations, helping them (groups or individuals) to increase the amount of land they cultivate. The goal is to enhance labor efficiency so that a smaller number of farmers can successfully cultivate relatively larger areas of land. This effort may solve some issues of agricultural recovery and restoration, many of which were thorny policy issues even before the disaster. The tsunami exposes the weakness of the socio-cultural systems in Japanese agriculture.

My anthropological field research was carried out in Miyagi prefecture's Yamamoto township, which is located in the southernmost coastal part of the prefecture and adjoining Fukushima prefecture (figure 1). The population before the disaster was 16,704. Yamamoto is a rural area whose economy relies mostly on the agricultural and fishing industries. It is known for its strawberries, apples, and Hokki sea clams (Sakhalin surf clam). However, its most important agricultural product is rice grown in local paddy fields. Although the net income from rice production is not great, 72 percent of Yamamoto's agricultural land is made up of paddy fields, and rice cultivation is the basis of the local farming industry. Farmers whose main products are strawberries or vegetables usually grow some rice, including a certain volume for self-consumption.

The 3/11 earthquake and tsunami struck the long, low coastline and swept away housing and businesses in Yamamoto township, inundating 80 percent of its farmland. The flooded area extended over 24,000,000 square meters (2,400 hectares)—37.2 percent of the total area of the township (figure 2). The disaster-affected area had 2,913 households, and a population of 8,990 persons, almost half of whom were in the town itself at the time. A total of 636 persons were killed and 3,302 houses were destroyed or severely damaged (Kokudo chiriin 2011; Sōmushō-tōkeikyoku 2011). The 1,440 hectares of paddy fields on record in 2010 were reduced to 657 hectares in March 2011, meaning that approximately 54 percent was lost. The loss ratio of vegetable field and garden agricultural land was 23 percent, relatively less than that for rice paddy land (table 1). The damage to rice production was, and remains, a complex and serious problem exacerbated by changing demographics and Yamamoto's complicated structure of property ownership (Yamamoto chō 2013).

In Miyagi prefecture, the number of farmers decreased 15.7 percent between

	2010	2011	2018 (estimate)
Population	16,704	14,628	13,700
Agricultural land	2,016 ha (31.7%)	1,122 ha (17.4%)	2,034 ha (31.5%)
Paddy field	1,440 ha	657 ha	1,432 ha
Field & garden	606 ha	465 ha	602 ha

Table 1: The agricultural recovery policy plan in Yamamoto Township in 2013 (Yamamoto chō 2013)

2010 and 2015. As of 2015, farmers over 65 years old make up 59.7 percent of this number. In terms of management, subsistence farmers (a legal category indicating cultivation of rice for self-consumption, not for sale) control 24.8 percent of the agricultural land, and their average plot is less than 0.3 hectares. Farmers who grow rice for commercial sale use 74.6 percent of the land. The size of rice farms across this land is distributed as follows: less than 1 hectare, 30 percent; 1–3 hectares, 33 percent; 3–5 hectares, 7 percent; and more than 5 hectares, 4.6 percent (Miyagi ken 2015). A notable feature in this distribution is the aggregation of small-scale plots, regardless of whether they are cultivated by subsistence or market-oriented farmers.

In 2015, the local administration of Yamamoto announced a policy for reconstruction of rice production to take place over several years. One element of this plan is the consolidation of land: the administration purposefully intervenes to push absentee landholders to rent their land to active or large-scale farmers. The target area is approximately 580 hectares of paddy field within the 937-hectare flood zone (Yamamoto chō 2015).

Research methods

The anthropological literature on rice farming in Japan is abundant, and it can be roughly classified into four categories. The first three represent conventional trends in research. One is related to the study of the anthropology of Japan, in which rice farming is seen as a keystone of Japanese culture and identity (Embree 2010; Befu 1971; Ohnuki-Tierney 1993). The second is exploration of the cultural history of rice farming in Japan using comparative perspectives from East and South Asian rural regions and focusing on rituals and worldviews (Yanagida 1969; Sugiyama 1967). The third category is the documentation of traditional knowledge and technology that prevailed before mechanization (Hayakawa 1973; Takeuchi 1976; Ogawa 1997). The last category centers on contemporary perspectives on rice production. Studies of this kind detail the function of environmental conservation as well as the inevitable socio-cultural changes brought about by use of new technology (Ishimoto 2014; Yasumuro 2012; Watanabe 2011).

Among these approaches, the third type suggests methodology that can be used to identify, classify, and prioritize local knowledge related to rice farming and to evaluate the possible role of this knowledge in the post-disaster setting of Tohoku. Established research (e.g., Takeuchi 1976; Hayakawa 1973), proposes three phases in the cultivation process of rice: (a) sowing-planting, (b) growth management and weeding, and (c) harvesting. One study (Takeuchi 1976, 28–32) noted that the threshing phase (c) had been mostly mechanized by the early twentieth century, and mechanization of sowing-planting (a) and the use of chemical fertilizer and weed killers did not begin until the 1950s. This article focuses on the local knowledge related to those three phases of rice production.

Like some other anthropologists who got involved in disaster research projects by chance (Oliver-Smith 2013, 276), I also started my disaster project by accident. I live in the city of Sendai, close to the epicenter of the 2011 Tohoku earthquake. The Miyagi prefectural government asked me to undertake organizing and carrying out a survey being planned for the local intangible cultural heritage in one area of the tsunami-affected region as part of a commissioned project (Takakura 2016). Being a local anthropologist, I organized my research team and sent them into a number of villages in the Miyagi coastal region between November 2011 and March 2013. By chance, the southern villages of Yamamoto township were included in my designated survey region, and I was asked to study in particular the local *kagura* dance and other performing arts associated with Shinto shrines. While engaged in surveying the damage caused by the tsunami to the local cultural heritage, I recognized other serious issues affecting the livelihood of the people working in agriculture in the area. That was the point of departure for the research project described here.

When I started this project on agricultural disaster and adaptation, I interviewed several specialists in the local agricultural cooperative and the agricultural technology development agency of the local government. Then I adopted the fieldwork method of focused individual on-site interviews. This approach involves repeated interviews with selected persons at the site of their activities in paddy fields during each different phase of the work calendar. I decided on this method because of the difficulty of typical participant-observation, both physically and ethically. Most individuals affected by the earthquake and tsunami still live in temporary housing, and it was difficult to find space for an anthropologist to stay in the immediate area.

I focused on two target farmers in order to explore the cultural dimensions of adaptation. Before the earthquake, these individuals both engaged in small-scale farming as a side job on land inherited from relatives. However, currently they are both classified as mid- or large-scale farmers. I visited each of them more than 40 times during 2011–15, covering all three phases of the work calendar plus the winter period of preparation for cultivation.

The first farmer, Mr. Takahashi (pseudonym, born in 1945), lives in the coastal area of Yamamoto. He lost not only his house and agricultural machinery but also five members of his family. While many neighboring farmers quit rice production, he expanded his cultivated paddy fields from 3 hectares pre-tsunami to 30 hectares. The second farmer, Mr. Adachi (pseudonym, born in 1943), lives in the mountainous part of the township, and thus suffered relatively little damage to his property. He had previously cultivated 1.5 hectares of his own ancestral plot and now works 3.5 hectares.

As the government set out to implement a plan to boost large-scale farming, some farmers increased the total area under cultivation because they took the land abandoned by other farmers. But the physical condition of paddy fields and plot size was the same as before. Both farmers in this study work multiple small paddy fields, investing the same amount of labor they did before the earthquake. Figure 3 shows one of Mr. Takahashi's cultivated agricultural land maps illustrating each plot and user, as of 2014. The initial "T" in the plot means one that Mr. Takahashi cultivates. Table 2 shows the rice farmer according to plot as numbered in figure 3, both pre- and post-tsunami. It shows a decrease in the number of farmers from 15 to 6. According to the Miyagi prefectural government, 70 percent of farmers had restarted cultivation in 2014. If the increased acreage of paddies was spread over one

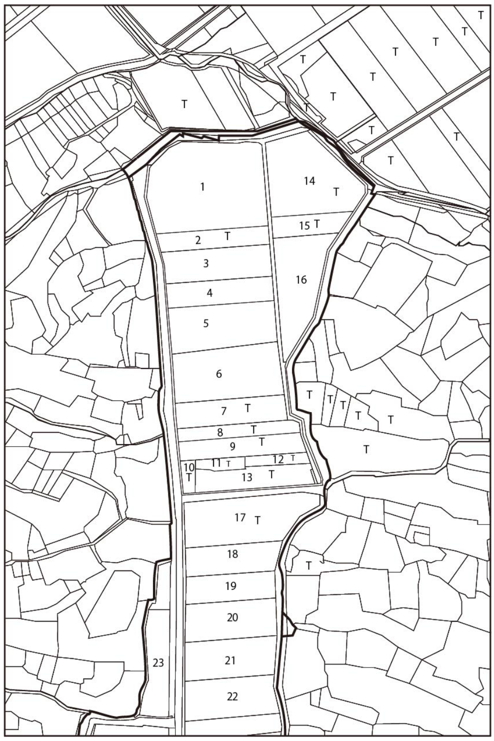

Figure 3: Agricultural plots in a part of Yamamoto Township in 2014. Image by the author.

extended field, the use of machinery would be effective and simple. However, conditions in the tsunami-affected region are too complex to allow for such an outcome. It is now necessary to examine how the farmers have been adjusting to this complexity and to discern the role of local knowledge of rice production in this process.

Traditions and innovations

Here, before examining the role of local knowledge in the disaster's aftermath, I take a brief look at some developments in rice production. I briefly review traditional practices before the 1950s, and then identify two critical technological innovations concerning seed rice that took hold before the disaster. One is a method of managing seed rice, and the other is the appearance of highly engineered seed rice. An account of these innovations is essential for appreciating farmers' adaptations following the tsunami.

Following practices that evolved over a long period and prevailed until fairly recently, Japanese farmers handed down their original seed rice through ancestral family lines, which produced not only the biological diversity of rice but also enhanced the identity of the family line (Ohnuki-Tierney 1993, 29, 181). This tradition has been gradually disappearing since the 1970s, and now it is almost extinct in this region. Increasingly rigorous quality control requirements on rice engendered by market demand have made it more difficult for farmers to achieve a substantial market share for their seed rice. Since the 1970s Japanese consumers

Plot number (in Figure 3)	User before tsunami		User after tsunami
1	A	⟼	D
	A	⟼	D
2	B	⟼	T
3	C	⟼	C
4	B	⟼	Q
5	D	⟼	D
6	E	⟼	P
7	F	⟼	T
8	G	⟼	T
9	G	⟼	T
10	H	⟼	T
11	H	⟼	T
12	H	⟼	T
13	H	⟼	T
	H	⟼	T
14	I	⟼	T
15	J	⟼	T
16	D	⟼	D
17	K	⟼	T
18	L	⟼	D
19	D	⟼	D
20	M	⟼	P
21	M	⟼	P
22	N	⟼	D
23	O	⟼	O
	15 persons		6 persons

Table 2: Property relationships and users in Yamamoto Township before and after the tsunami. Table by the author.

have become accustomed to buying rice with brand names, such as Sasanishiki or Koshihikari, which people perceive as having especially good quality and flavor. In 1978 Miyagi prefecture began promoting intensive seed rice production, centered in one region, and started to sell breed-controlled seed rice to farmers through the local agricultural cooperative. Most rice farmers today in Miyagi buy these types of seed rice. They are not hybrids, but controlled products of the original seed rice.

Traditionally there are three types of seed rice distinguished by when they come into ear: *wase*, earlier ear; *nakate*, middle ear; and *okute*, later ear.[1] These expressions refer to types of rice and stages of childhood development: *wase* can also mean "precocious child," while *okute* can mean "late bloomer." Farmers in Yamamoto can buy nine types of "brand" seed rice. According to the local people, Kirara is the sole type of *wase* or early ear, which comes into ear around July 15–20. The five brands of middle ear are known as glutinous rice: Tsuyahime, Hitomebore, Sasanishiki, Manamusume, and Mochigome. They usually come into ear between the end of July and 10 August. There are three brands of the later ear, Koshihikari, Kaguyahime, and Mirukī kuīn (Milky Queen). These come into ear around August 13–15, which coincides with the Bon festival, when annual Buddhist rituals related to honoring the ancestors take place. Each of these brands of seed rice has a unique taste and a slightly different coming-into-ear period, even those that are in the same general categories of *wase*, *nakate*, and *okute*. Selection of seed rice is a critical decision for farmers, who must take into account the critical variables of market value, weather, and labor availability.

Purchasing seed rice is similar to futures trading. In principle, farmers book advance orders of seed rice in 5-kilogram units because seed rice production depends on these orders. If the ordering period is in February 2017, deliveries would come in March 2018. An order cannot be revised or cancelled. Mr. Adachi, described this process as follows:

> When I order seed rice, I need to decide what to get by predicting the weather for the year myself. In this region, we often have years without a definite end to the rainy season. Therefore, we are always worried about whether we should plant the *wase* or the *okute*. For example, Koshihikari, a type of later ear, is a seed resistant to cold. It is important not only to choose the right type of seed rice but also to decide when it should be sown. This affects my labor calendar.
>
> (Interview, July 24, 2014)

Aware of the nature of futures trading when they purchase seed rice, farmers choose one or several types among the nine varieties, taking into account labor conditions and business strategies. Their decisions are based on the different growth characteristics and circumstances that affect the market value.

The second pre-disaster technological innovation is engineered rice; seed rice is coated in a substance containing iron powder, which makes the seeds heavy enough that they can be sowed directly on paddy fields. By the conventional method, Japanese farmers first sprout unhulled seed rice, then lay the sprouted seeds in separate nursery beds. When the sprouts have become seedlings, they transplant the seedlings to the paddy field, which by then is filled with a shallow layer of water. This process is known as *taue*, or rice-transplanting. Planting seed rice directly in a field without the layer of water is called *chokuha*. The seeds are planted in the soil, they sprout and grow a little, and then farmers sluice water into the field. This is the reason for coating the seeds with iron. Because of the weight of the iron, the seed rice does not drift when the field is flooded and takes root in the ground. Another reason for the iron coating is protection against bird picking. There are two ways to carry out *chokuha* direct seeding, either by helicopter or seeding machine. Helicopter seeding can be done quickly, which makes it possible to sow an extended agricultural plot very efficiently. Seeding machines take more time, but they sow the rice seeds in lines, which affords greater harvest yields than in plots planted by helicopter.

Direct seeding of rice coated with iron powder is certainly a new technique, but the *chokuha* process itself is as old and well established as the traditional *taue* transplanting process. Japanese folklore researchers regard *chokuha* as an archaic method, which they found had almost disappeared by the 1960s (Ogawa 1995). Interestingly, the current practice of *chokuha* direct seeding is not a revival of old methods; its inception can be traced to California rice farming in the United States (Yamauchi 2012). Because direct seeding by machine increases labor efficiency, the Japanese agriculture ministry and related agencies decided to introduce it in this country. The method is still being developed, however, and so far it is used in only a small percentage of farms in Japan.

Local knowledge in post-disaster adaptations

How have local farmers restarted rice production amid the conditions left by the disaster? My focus is on those farmers who have been expanding their cultivation in the absence of an increase in available labor. Here, I demonstrate the role of local knowledge in implementing adaptive methods according to each process of sowing/planting, growth management/weeding, and harvesting.

Choices made in sowing and planting

Both farmers I interviewed adopted the *chokuha* direct seeding technique for their land after the disaster. They adopted it only partially, however. When I asked Mr. Takahashi why, he explained:

> The reason for the mixture of the direct planting and rice-transplanting methods is the different harvest periods that result from the two cultivation methods. When one uses the rice transplanting method, it is possible to reap the rice from the beginning of October, while using the direct method, reaping usually begins on approximately October 20. Using both, a single farmer can stagger the labor time required for an extended plot. There is certainly another way to distribute labor time; it is based on using a type of seed rice that has its own period of reaping. When farmers plant these seeds, they plan on different reaping periods, taking into account the timing and labor required. In terms of market sales, however, this method poses difficulties for the following reason. After reaping, the next process is threshing by machine. Japanese consumers are very sensitive to distinctions among varieties of rice, and it is impossible to sell rice mixtures. Each type of rice must be threshed separately so it does not mix with other types. Farmers usually have their own machines, and so when they thresh a different type of rice, they must clean the machine thoroughly, which is very labor intensive. (Interview, July 4, 2014)

In 2014, Mr. Takahashi planted three types of seed rice and used two methods of planting. Figure 4 is a group of photographs of his paddy field on July 4, 2014.

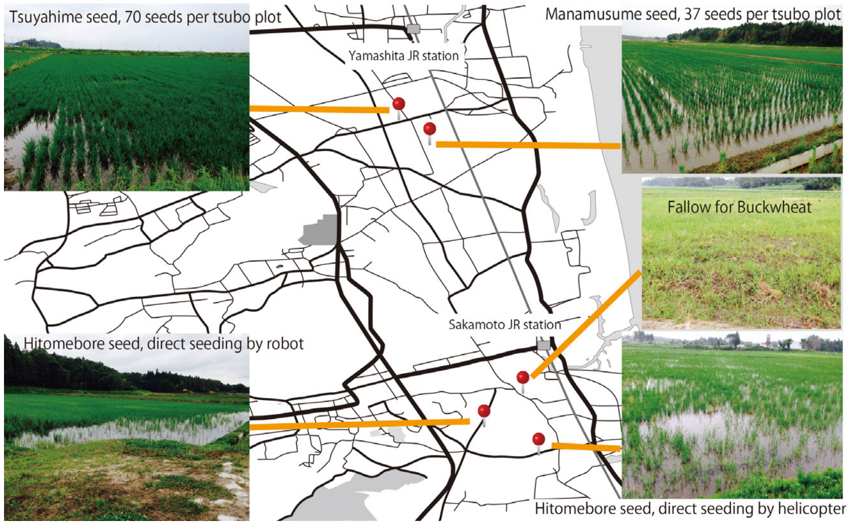

Figure 4: Various conditions of paddy fields on July 4, 2014. Photograph by the author.

They show four different types of seed rice and planting methods, all separate from each other, in his cultivated fields. The first is Tsuyahime seed rice planted by the seedling-transplantation method; the second is Manamusume seed rice also using the transplantation method. However, for Hitomebore seed rice, which is the seed rice for his major production, Mr. Takahashi used both the direct seeding and transplantation methods in separate fields.

Although one might assume that the idea of farm scheduling—managing agricultural timing—either by the planting method or type of seed rice, is related to recent agro-technological developments, this is not the case. Mr. Adachi explained to me two methods of rice seedbed (*nawashiro*) that are used in preparation for rice transplanting. These methods were employed even before the mechanization of agriculture in the 1960s. These methods allow a farmer to organize time shifts for a viable work schedule. In the *mizunawashiro* method, which is considered to be archaic, seed rice is planted in dedicated nursery plots of paddy fields that are saturated with water. In the *ho'onsetchū* (*-nawashiro*) method, farmers plant seed rice directly in dedicated plots with soil in paddy fields and then cover the seedlings with plastic sheets or oiled paper. This method was invented in the 1930s. The seedlings grow until they are 10–15cm in height, and then they are planted in the paddy fields. The *ho'onsetchū* method is two weeks shorter than the *mizunawashiro* method. According to Mr. Adachi, because of labor limitations, the ability to manage time in that way was crucial before the introduction of rice-transplanting machines in the 1960s (interview, July 24, 2014).

Farmers have to confirm whether the young plants are firmly rooted in the paddy field after transplanting. Figure 5 shows rice plants from paddy fields managed by Mr. Adachi. The pictures are of young plants showing roots of two colors three days after planting. Plants with white roots were transplanted from the nursery bed, and those with brown roots grew from seed planted directly in paddy field.

Figure 5: Two colors of rice seedling roots (May 21, 2015). Photograph by the author.

When young shoots have roots with these two colors, that indicates that the rice transplanting has been successful, and the directly planted ones are also successful.

Farmers face another choice when they plant; this concerns the amount of seed rice planted per plot, measured by *tsubo*, a Japanese unit of area equal to about 3.3 square meters. Planting a greater number of seeds per *tsubo* increases the cost of purchasing seed rice. The effects of this choice are physically apparent in the width of the space between seedlings in a paddy field, created by automated rice-transplanting machines. Figure 6 shows three different widths: when farmers plant 70 seeds per *tsubo*, the space between the rows will be 9 cm wide two months after transplanting; for 40 seeds per *tsubo*, it will be 14 cm; and for 37 seeds, it will be 20 cm. Most of the farmers in the Yamamoto area plant 70 seeds, the amount recommended by the local agricultural cooperative.

Even so, both of my informants choose to grow fewer plants per *tsubo*. Mr. Adachi plants 40 seeds and Mr. Takahashi, 37 seeds. They are very sensitive about the cost of seed rice. Mr. Takahashi explains his reasoning:

> I chose to plant 37 seeds this time, which was a challenge. Here most farmers plant 60 seeds or more. Planting 37 seeds is an exception to standard practice, and reflects a choice that it will lead to an inevitably smaller harvest. The greater the number of seeds, the greater the harvest. This certainly points to the drawbacks of planting a smaller number of seeds. But there are merits: lower costs and good growth conditions for the seedlings. If one plants a small number of seeds, the space between seedlings is wider; therefore, growth is faster, and the seedlings grow thicker. Looking toward the final results, the harvest can be expected to be not much smaller than that of a 70-seed planting. The wider space also helps prevent disease in the rice. (Interview, July 4, 2014)

70 seeds, 9 cm width
between seedlings

40 seeds, 14 cm width
between seedlings

37 seeds, 20 cm width
between seedlings

Figures 6 a, b, & c: The different width of seed rows per *tsubo* plot, which varies according to the number of seeds planted (July 24, 2014). Photograph by the author.

These are things he has learned from experience. He concluded that planting a comparatively small number of seeds per *tsubo* is better than planting a larger number. In addition to the issues noted above, if one plants as many as 70 seeds per *tsubo* in a paddy field, that creates competitive conditions among seedlings severe enough to require a significant increase in the amount of fertilizer that must be applied to ensure the seedlings grow tall enough (interview, August 25, 2014).

This farmer's choice of seed number might appear to be related to the mechanization of rice transplanting. Actually, this choice also is grounded in traditional technology. Anthropologist John. F. Embree provided an interesting ethnographic description of rice transplanting and the role of field workers as linemen before World War II:

> It [*taue* rice-transplanting] is hard work, but the work is social. Ten or fifteen young men and women are lined up across a field. As two linemen lay down a guide line with beads every five inches, the human line bends over rapidly, sticks seedlings into the mud, then stands up, and steps back; the lineman shouts Hai!, moves the string over five inches, and the human line again bends over and pops in the seedlings. The monotonous work is relieved by a constant chattering [that is] often ribald. (Embree 2010, 99–100)

While in the traditional setting the linemen, as leaders of social labor, determined the amount of space between seedlings, a present-day farmer using mechanized rice transplanting can select the width by him/herself. Needless to say, this kind of mechanization is an efficient reflection of traditional techniques.

Before the earthquake and tsunami, neither farmer ever decided to work with a combination of several choices among methods of sowing and planting because

Draining water in paddy field

Rice tiller

Figures 7a&b (below): Halting growth of rice tiller by cutting the water supply (July 9, 2015). Images by the author.

their paddy field plots were very small. They chose Hitomebore seed rice, and they used the rice transplanting method as a matter of course, keeping to the seed numbers per *tsubo* recommended by the local agricultural cooperative. While many farmers abandoned paddy field cultivation after the disaster, others chose to cultivate extended paddy fields in response to efforts by the local government to support the recovery of rice production and to facilitate the consolidation of land-use rights. In short, farmers who are restarting rice cultivation confront larger paddy field areas and a shortage of labor. Local knowledge of sowing and planting is contributing to their efforts to adapt to the new conditions by making their work calendar less intensive and increasing their labor efficiency.

Basic skills of growth management and weeding

After rice transplanting, farmers must pay attention to the tillers that emerge from the seedlings. A tiller is a lateral shoot emerging from the base of a rice stem. As tillers grow, the number of shoots [tillers] growing from the root increases by 15 to 20. Later the tillers become stalks. Farmers control the amount of water in the paddy fields as a way to ensure strong and healthy tillers. The tiller is the basis of growing rice plants that will not topple even as harvest-time nears. Farmers temporarily drain water from paddy fields in order to stop tiller growth. When seedlings are planted in a paddy field in early May, 15–20 stalks appear from each root in the flooded soil. However, tiller growth ceases when the water is drained out. Figure 7 is a photograph of this process. According to Mr. Takahashi, the temporary draining of water affects rice plant growth in the following ways:

> The young stalks grow longer in paddy fields with deep water. Because the submerged stalks are not comfortable in the water, they try to grow faster. This makes the length of stalk between nodes longer. When rice stalks grow in such a way, they may topple as they keep growing before the autumn harvest.
>
> (Interview, July 9, 2015)

Farmers consider stalks with a shorter length between the nodes in their lower part to be resilient against wind and rain. Thus they carefully control the water level in the paddy fields and sometimes drain the fields. Some paddy fields have a water plug connected to the waterway running through them, which allows easier draining.

Another important aspect of growth management is predicting the appearance of the rice ears, the part of the plant that forms the rice grains. Local farmers observe the top leaves of the plants from the end of July to early August. If the leaves are bent, an ear should appear. The farmers call this *tomeha*, indicating that a plant has a different color from the others. The reason for the bending is the weight of the ears. Although the sowing of seed or transplanting of seedlings begins on the same day for each field, the appearance of ears may vary slightly within the field (see figure 8). After the first signs of *tomeha* bending in some plants, it usually takes five days for this to occur in all plants in a paddy plot (interview with Adachi, August 5, 2014).

The stage when all the ears of the plants in a plot of paddy field are bent is known as *hosoroi*. Figure 9 shows a rice paddy during *hosoroi*. In this period, the

Tomeha

Premature ear inside *tomeha*

Figures 8 a & b (above): Local concept for judgment of rice ears. Pre-mature ear inside *tomeha* (August 5, 2014). Photograph by the author.

young yellow-green ears appear to be in full bloom between the leaves, which indicates pollination. When farmers confirm a paddy is in *hosoroi*, they feel a sense a relief and look forward to the harvest.

June to August is the main period of weeding. Farmers usually use weed-killer, although often they also need to cut weeds by machine in some places. Weeding is nothing but continuous hard labor. Farmers know when they must weed by the way the plants respond to weed growth. According to Mr. Adachi, the height of the stalks in a plot ideally should all be equal; it is aesthetically pleasing but also beneficial for growth management. Farmers pay attention to the ridges of the paddy fields, namely the ridges surrounding paddies, which are more difficult to weed than other parts of a field. When weeds on the ridges are not sufficiently cut, adjacent rice plants will grow longer so as not to lose sunlight to the weeds on the ridge; the shade from weeds stimulates the rice to grow taller and results in

A rice ear in *hosoroi*—pollination period

Rice ears in full bloom in a paddy field

Figures 9a&b (above): *Hosoroi* or pollination period (August 5, 2014). Photographs by the author.

Figure 10: Shiko in rice (August 29, 2014). Photograph by the author.

disproportionate heights of rice in the paddy. The farmers dislike such tall stalks because they are more vulnerable to damage by wind and rain. This kind of local knowledge does not directly help farmers adapt to post-disaster conditions, but it is fundamental knowledge needed for understanding the maturation of rice.

Harvesting

How do farmers judge the best time for harvesting (*minoiri*)? Generally, the degree of rice maturity can be roughly gauged by sight, but that is not enough to determine the exact timing of the harvest. Farmers have a way to calculate the appropriate time by focusing on the color of the stalk, known as *shiko*, bearing the rice ear (figure 10). When the *shiko* turns the same yellow color as the ear, this means the rice is mature. Maturity develops as the tip of the ear turns from green to yellow, and then the yellow color moves further down the stalk. This process takes place over several weeks. According to Mr. Adachi, rice with *shiko* as shown in figure 10 will take another twenty days to reach full maturity. This knowledge allows farmers to estimate the time of maturity for each type of rice. When the yellow-colored *shiko* comprises approximately 70 percent of a paddy field, the rice is ready to harvest. This judgment is important because if farmers wait until 100 per-

Good maturity

Bad maturity due to less sunshine

Figures 11a&b: Sunlight and plant growth in the same paddy field plot (August 31, 2015). Photographs by the author.

cent of the plants reach this stage, some of them will be too mature. Their grains will have lines down the middle, and they will crack when polished in a machine. "All the rice in a paddy field does not simultaneously mature, so the point is to recognize the optimal time to maximize the volume of harvest" (interview with Adachi, August 29, 2015). Local knowledge of *shiko* is critical for the best possible estimate in planning the harvest schedule.

Japanese farmers are known to be sensitive about the aesthetics of their fields. They prefer paddy fields with neat lines of stalks of the same height. A farmer's ability to organize an aesthetically pleasing paddy field is considered socially valuable to the community (Watanabe 2005). This can be seen immediately in Yamamoto township. The farmers care about whether the growth process creates a beautifully crafted rice field in the last stages before harvest. They note carefully how sunlight affects the maturity of the rice ears and how this affects differences in the growth of the rice plants. Figure 11 compares levels of maturity in one plot of a paddy field on August 31, 2014. The top picture shows healthy maturity because most of the ear tips, having received adequate sunlight, are bent sufficiently, while the stalks in the bottom photograph suffer from insufficient sunlight. The latter are located near a bank, which creates shade. Farmers carefully observe their rice fields daily to judge slight differences in stalk growth. They are also sensitive to the effects of fertilizer; the amount used affects the strength of the rice stalks. The more fertilizer that is applied, the taller the stalk grows, which often results in typically weak "back and legs" of the rice that can easily be toppled by wind and rain. The ideal stalk is low and wide. However, even when farmers recognize bad conditions in a given year,

Figure 12: Different colors of paddy field, September 26, 2014. Photograph by the author.

they cannot ameliorate problems in growth during that year. The experience adds to knowledge for the following year's cultivation.

The farmer's choice of seed rice, the method of sowing-planting, and the number of seeds per plot (in rice-transplanting) create various and delicate differences in harvest timing. This becomes apparent in the color of a paddy field. Although fields may appear to be homogeneous throughout much of the growing season, each paddy plot simultaneously displays a different color graduation from light green to yellow. Figure 12 shows the results of farmers' choices. The yellow and green of the fields show that the front light green field was planted with Tsuyahime seed rice, having a late type of middle ear; the back yellow field was planted with Hitomebore seed rice, an earlier type of middle ear. According to Mr. Adachi, his neighbor, who owns the back plot, planted rice seedlings two days earlier than he did in his front plot. As a result, on September 26, 2014, the front plot had another two weeks until harvest, whereas the back plot was ready for reaping. If one of these farmers had chosen the *chokuha* direct-seeding, the harvest would have been further delayed. These two farmers' complex choices of seed rice and dates of seedling transplantation produced more than ten days' difference in the timing of the harvest.

Local knowledge of harvesting, also, does not contribute directly to the farmer's ability to adapt to post-disaster conditions. Rather, adaptive activities, such as choices of seed rice and methods of sowing-planting, result in different periods of harvesting and color gradations in the paddy field. The farmer's knowledge of harvesting enables him or her to recognize exactly when to harvest in paddies with different types of rice and planting methods.

Discussion

This paper examines the many effects of farmers' local knowledge on rice production, from the selection of rice seed and decisions about sowing-planting to growth management and harvesting. While farmers may be able to calculate differences in the rate of growth, either by their choices of seed rice or methods of sowing-planting, they are also able to carefully foresee the growth process and recognize different conditions of growth in the fields. One cannot help noting that farmers speak of the ideal shapes of the rice grains and rice plants in human terms (for example, back, legs, and so on). Shorter and wider stalks are resilient against heavy rain and wind. Such ideal plants are known as "rice with a strong lower back and legs." The knowledge clusters surrounding rice cultivation can be summarized in terms of manipulation of time for labor. The growth of rice as a plant proceeds by photosynthesis and biological responses to natural conditions, including precipitation, temperature, sunlight, soil, and wind. The farmers create differences in rice growth through the use of their local knowledge to maximize labor efficiency.

Theoretically, farmers in Yamamoto township can create forty-five different work schedules depending on their choices of agricultural methods. First there are the five patterns of rice sowing-planting. There are mainly two ways of planting: the *chokuha* direct-seeding of iron-coated seed rice and *taue* seedling transplantation. For the former, there are two methods—seeding by planting machine or helicopter. Among the latter there are three options for the number of seeds planted, namely 37, 40, and 70 per *tsubo* of the plot. Additionally, farmers can choose among nine types of seed rice from three categories of growth, including *wase*, *nakate*, and *okute*. These all add up to forty-five options, each of which could generate a slightly different growth process in any given plot. It is important to note the land use structure of Yamamoto township. There are thousands of tiny paddy fields with complex property relationships. Each farmer needs to consider the most appropriate way of sowing, growth management, and harvesting while taking into consideration his or her own labor capacity. In the post-disaster circumstances, the disaster recovery policy encouraged some farmers to increase the amount of land they cultivated, but the conditions of the plots themselves remain as they were before the disaster. That is, they remain highly segmented. In a region with limited labor availability, farmers need to find the most efficient methods of pursuing their business. This leads to the concept of time manipulation as agricultural local knowledge. Farmers have had such knowledge for a very long time, but its importance, especially as it relates to sowing and planting, has increased since the disaster.

How do paddy field farmers use their local knowledge of agriculture to adapt to post-disaster conditions? First, I would like to examine the dynamism and complexities of local knowledge to show how it is applied to the disaster reconstruction process. Local knowledge of rice production could be classified under three categories: (1) maturation process, (2) environmental knowledge, and (3) biological response (see table 3). Maturation process knowledge relates to the form of the concept, and is embodied in terms expressed in the local dialect, such as *tomeha*, *hosoroi*, *minoiri*. This knowledge is fundamental because it provides a basis for recognizing and describing the rice growth process. It also acts as a medium for communication among the local farmers. Farmers exchange information on rice growth and harvests using these terms with dates or amounts of fertilizer. These two types of knowledge, environmental conditions, and maturation processes, are collective and traditional in nature.

Environmental knowledge pertains to the relationships among soil, water supply, sunlight, and the time frame available for rice production. This is

Type of knowledge	Feature	
Maturation process: *tomeha*, *hosoroi*, *shiko*, etc.	conceptual, communicative	collective
Environmental conditions: soil, water supply, sunshine, etc.	descriptive, prescriptive	traditional
Biological response: sowing type, number of roots, weeding, and fertilizer	conditional, human-plant relationship	individualistic, innovative

Table 3: Three systemized types of local knowledge. Table by the author.

prescriptive knowledge with a descriptive form relating to the physical condition of rice growth. Examples from this research are the effect of water supply on stalks (growth management), and the effects of sunlight on the harvest process. Additionally, local farmers recognize the potential difference in harvests, depending on whether plants are grown in the sandy soil along the coast or the clay-ish soil inland. This knowledge is common among the local people and it allows them to roughly estimate the harvest capacity of an agricultural plot.

The last, biological response knowledge, relates to human–plant interaction. It is often expressed in conditional verbs and statements of anticipated results. We can see this in farmers' comments that if one took a particular action in the paddy field or some environmental event happened, this would have a specific or particular result. Examples are the choice of rice seed type, decisions to use direct sowing or seedling transplantation, and the calculation of the amount of seeds in a plot. Knowledge of weeding and fertilizer effects belongs to this category. Each farmer has a different view of certain actions and methods. The more skilled farmers are, the more knowledge they have. Importantly, there is an individualistic and innovative aspect of this type of knowledge. Farmers always need to adjust their methods and technological innovations in response to different climate, soil, or economic conditions.

The local administration has provided new production technology (means of production) and new arrangements for land property (production relations) through its disaster reconstruction policies. The success of a farmer's adaptation to the post-disaster conditions depends on his or her level of engagement with the three types of knowledge. The first two types, the maturation process and environmental knowledge, tend to be traditional and collective in the community. However, the innovation and differentiated experience of biological response knowledge could lead to critical adaptations by farmers to the new circumstances. Farmers can gain knowledge about the maturation process, then environmental knowledge from their families, and develop the biological response individually. The three kinds of local knowledge are evolutional in nature.

Conclusion

The focus of this paper has been to explore the role of local knowledge of rice production in the circumstances that have prevailed since the 2011 Tohoku disaster. I have shown how this knowledge is structured in a complex and dynamic way, and I have demonstrated that it has both traditional and contemporary dimensions. Local knowledge of paddy fields consists of indigenous wisdom passed down through several generations, but it also contains flexible and adaptive aspects enabling farmers to cope with unknown difficulties. It is collective in character but also allows for individual differences that make possible its continual renewal.

There are many varieties of local knowledge of rice production in the tsunami-affected region, but overall this knowledge can be characterized as enabling the manipulation of time. It gives farmers the ability to choose the best conditions for labor efficiency in cultivating a given land plot. Local knowledge falls in three categories: (1) maturation process, (2) environment, and (3) biological response. All three involve knowledge of cyclic and seasonal natural phenomena in relation to the climate and environment of local plant life, which can be seen as local or ethno-phenology. This knowledge supports farmers' resilience in the post-disaster period.

Previous studies on disaster risk reduction and indigenous knowledge tended to focus on the cultural origins of knowledge and its continuity through several generations. I understand my approach as representing new concepts relating to disaster risk reduction science and policies. Biological response knowledge is a more innovative type of knowledge in this field, since it is acquired by individuals and associated with the introduction of new technology and social institutions. However, it is the powerful and adaptive aspect of this knowledge that creates new capacities to cope with previously unknown conditions.

The three categories of knowledge are integrated in the collective mind of the farmers. Therefore, disaster risk reduction scientists and policy-makers should carefully identify the dynamics and complexities of that indigenous knowledge and provide robust support for its application in disaster-related circumstances. Agricultural policy makers should encourage the transmission of maturation-process and environmental knowledge as a cultural legacy from one generation to the next, along with the fundamental knowledge of traditional technology. In addition, it is important to reinforce the spread and use of biological response knowledge. This type of knowledge can suggest solutions for farmers facing unforeseen difficulties after a disaster, including ways to recover production even when labor power has been reduced. Some farmers with greater knowledge in this area may hesitate to share it with others, because it is directly related to their business. Policy makers involved in disaster risk reduction should help to create opportunities to share individual biological response knowledge as much as possible among local people. If these three systemized types of knowledge were spread more widely, they would greatly support a community's capacity to adapt in a post-disaster agricultural setting.

When a tsunami causes serious damage to agriculture, one may regard the economic assistance to farmers and civil engineering measurements for farmland as universally applicable physical-economical policies. However, the cultural dimension of the post-disaster risk reduction could not be so generalized. Therefore, I would like to emphasize the importance of the perspective of dynamic and complex indigenous knowledge of agriculture in three categories: maturation process, environment, and biological response. It would help convey more widely an understanding of the social processes that take place as farmers adapt to post-disaster exigencies with their traditions and innovation, and it would also contribute to policy recommendations in different localities.

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Note

1. There are several ways of rendering the terms in kanji: *wase* as 早稲 or 早生; *nakate* as 中稲 or 中手; *okute* as 晩稲, 晩生, or 奥手.

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