Chapter 12
Attempt to Develop High-Value Rice in the Shimojin District, Mashiki Town, Kumamoto Prefecture: Transition Into Sustainable Local Community Using Disaster Recovery from the 2016 Kumamoto Earthquakes as a Branding Strategy

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Abstract In this chapter, we report the case of a co-design project undertaken in the Shimojin district that was severely damaged by the 2016 Kumamoto Earthquakes. We, IDS3, and local residents have not only attempted to recover the aforementioned district from the damages it suffered due to the earthquakes but also unite its entire community, which is currently suffering from population decline and aging. To supplement its local agriculture, we initiated the co-design project as a means to promote rice branding by adding value by utilizing the biodiversity in the district and transforming the district's rice paddy fields into eco-friendly paddy systems. We were involved with the project since the consensus building phase owing to our co-design experience with regard to restoration planning at disaster restoration sites and knowledge about the district. We primarily conducted our research in three fields: (1) design of the recovery plan of eco-friendly paddy fields and agricultural ditches, (2) consensus formation for rice branding, (3) exploration of eco-friendly farming method suitable for the region under study.

Keywords Co-design · Co-production · Disaster recovery · Community invigoration · Eco-friendly farming · Brand rice

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1 Introduction

Due to the 2016 Kumamoto earthquakes, paddy fields in Mashiki town suffered serious damages. Before the occurrence of the earthquakes, the Institute of Decision Science for a Sustainable Society (IDS3) has been implementing research for the winter flooded rice paddy fields in the Shimojin district, Mashiki town to improve regional water cycle and biodiversity, developing a cooperative relationship with the local community and companies (Fig. 12.1). Based on the relationship, we, IDS3, have offered to design the recovery plan of eco-friendly paddy ditches as a part of the recovery plan of the rice paddy fields in the Shimojin district from the 2016 Kumamoto Earthquakes.

In contrast, preserving the local community in the Shimojin district is becoming an increasingly challenging task owing to the declining trend of birthrate and aging population and the ever-increasing flow of young people to urban areas. In view of the future of the Shimojin district, it was considered that the revitalization of the local

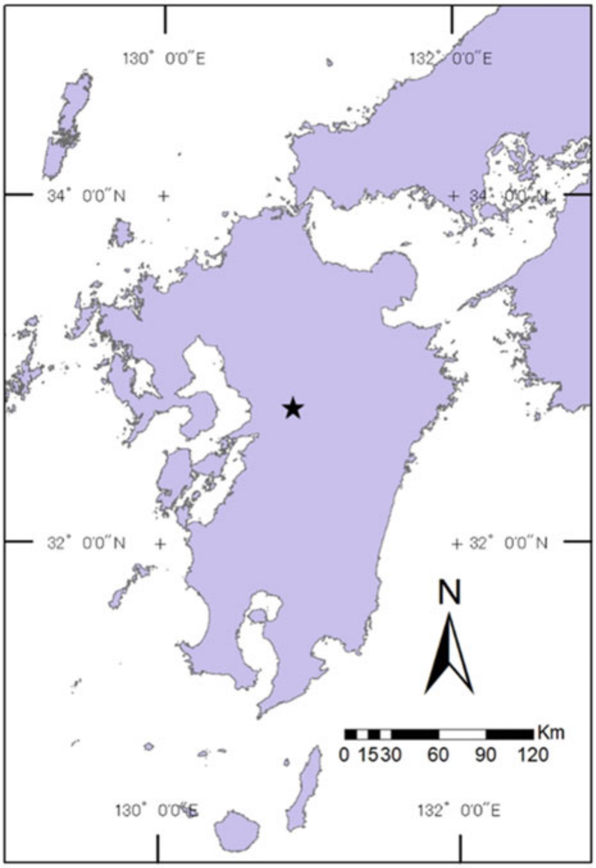

Fig. 12.1 Location of the Shimojin district, Mashiki Town

community and establishment of sustainable local community should be given the highest priority. For this, we proposed the production of high-value rice branded by eco-friendly farming and eco-friendly rice paddy fields to promote rice production in the local community, which is a major occupation in the district and can therefore lead to an increase in employment opportunities. We proposed that the recovery of rice paddy fields is a good way of rebuilding rice paddy fields, thereby contributing to a branding strategy for high-value rice production.

Because the establishment of a branding strategy initiated by IDS3 does not lead to sustainable and autonomous agricultural management by the local entity, co-design, and co-production process was considered to be the most suitable for the success of a new branding strategy and was thought to help localize the branding strategy.

Therefore, we conducted research in three fields: (1) design of the recovery plan of eco-friendly paddy fields and agricultural ditches, (2) consensus formation for rice branding, (3) exploration of eco-friendly farming method suitable for the region.

2 Background

2.1 Effort for the Development of High-Quality Rice Production Before the Earthquakes: "Winter Flooded Rice Paddy Fields" and "Shimojin Organic Agriculture Research Group"

Kumamoto city is famous for its abundant groundwater resources, as roughly a million people in Kumamoto city use groundwater as their primary source of water supply (Imasaka 2014). This city is therefore also known as the "Groundwater city." In addition, a beverage company has a large-scale beer factory shipping its products to western Japan owing to the city's plentiful groundwater resource. Groundwater is an important resource in this area both socially and economically.

In the past few decades, groundwater levels in the surrounding area of Kumamoto city have been decreasing because of the increase of impervious areas such as residential area and the decrease of the pervious area such as paddy field area (Kumamoto Prefecture 2008). A winter flooded rice field is conducted irrigation in the winter season (fallow period), which is the way to increase the amount of infiltration from each paddy field. In the area, winter flooded rice fields are introduced by the subsidies from local governments or the beverage company (Kumamoto Prefecture 2008) The beverage company has also been conducted its own winter irrigation subsidy for the rice paddy fields in the groundwater basin of its beverage plant where includes the Shimojin district (Yamada 2013). Over 3 ha rice paddy fields in the Shimojin district have been conducted winter irrigation under the various subsidies.

Notably, winter flooded rice fields in the Shimojin district is to focus on the quality of groundwater to be recharged. Based on the cooperation of volunteers of local farmers and guidance by the beverage company, making a rice by organic agriculture not using pesticides and chemical fertilizers to get pure groundwater. For the purpose of reducing the environmental burden on groundwater and product high-quality rice by organic agriculture, local farmers and the beverage company are organizing "Shimojin Organic Agriculture Research Group" and conduct study sessions inviting organic agriculture experts. We, Kyushu University IDS3, joined the research group in charge of the environmental evaluator of organic agriculture.

2.2 Damage to Paddy Fields in the Shimojin District Caused by the 2016 Kumamoto Earthquakes

On April 14 and 16, 2016, two enormous earthquakes caused serious damage to the Shimojin district, Mashiki Town. These earthquakes were caused by the Futagawa fault across Mashiki Town, and the fault line moved 2 m as a result of serious damage caused to the villages and farmland in the area (Fig. 12.2).

Out of the 100 paddy fields (accounting for 20 ha in total) in the Shimojin district, 60 paddy fields were cracked. Almost of non-damaged paddy fields also became impossible to farm because the irrigation channel system in the district was broken. The afflicted agricultural land in Kyushu became an enormous scale, and the agricultural land restoration project by the Ministry of Agriculture and Fishery took two to three years to complete a restoration of farmland from the application by its farmer. The beverage company, who has been doing the winter flooded rice fields project in the Shimojin district, decided to restore the paddy fields, regardless of the farmland restoration projects by the Ministry of Agriculture and Forestry for its own sake to restore the groundwater used its plant promptly.

To co-design a restoration plan among the company, local people, and local governments, a consensus is required to be formed for the restoration of paddy fields. We, Kyushu University IDS3, join the consensus building as one of the facilitators, because we possess co-design experience relating to restoration plans at disaster restoration sites and are well acquainted with the district.

3 Consensus Building Process in the Damaged Paddy Restoration in the Shimojin District: Why Did We Aim for High-Value Rice?

To understand the current situation and identify the problems that need to be solved in the Shimojin community, reminiscent talks (called "Mukasigatari" in Japanese) concerning the district were conducted several times (Fig. 12.3). A reminiscent talk

Fig. 12.2 Damaged paddy fields in the Shimojin district

Fig. 12.3 Picture of a reminiscent talk taking place. Local people talked about the old days based on the map describing the ancient conditions of this district

is a meeting wherein the local residents discuss and recall the memories of the old days when the community was full of energy. Comparison between the past and present of the Shimojin community acted as a clarification of the image of an ideal situation of the community in the future. We conducted two reminiscent talks, which are listed as follows:

- The first reminiscent talks (November 14, 2016)
- The second reminiscent talks (January 10, 2017)

It is important that a maximum number of people participate in the aforementioned talks, thereby forming a local entity to collectively tackle the problems of the community, because participation creates a sense of responsibility with regard to community affairs. We mailed invitation letters and newsletters that targeted absentees to all the local residents of the community. Participants were encouraged to recall the memories of other participants by talking about old memories. This in turn worked as a common language, wherein every community member could engage in and enjoyed reminiscing. By sharing information and feelings during these talks, relationships of local people were strengthened, and a common purpose and belief are developed toward a future community. Reminiscent talks are also effective when overcoming existing conflict between local people such as relationship and interest conflicts.

In the reminiscent talks, a local resident said the following regarding the future of Shimojin rice fields; "I want to leave the rice fields in the Shimojin district and hope children of future community will have an experience to eat the Tanishi snail and the Dojo loach in the rice fields and diches without having to worry about agricultural chemicals just like old days." As a common view created by the two times of reminiscent talks, people of the Shimojin community found virtue in the nature of the district and hope the past relationship between the local nature and people will recover in the future.

Two reminiscent talks deepened our understanding of the future of Shimojin rice fields that the local residents hoped to see. We therefore moved to the stage of the workshop where the future Shimojin rice fields was discussed with the local people (especially those who were involved in the winter flooded rice paddy fields). The name of the meeting was "Iki-iki rice field meeting," wherein Iki-iki means "full of energy" in Japanese. The name was given in the hope that the community will be vibrant just like it used to be.

- Iki-iki rice field meetings were held five times;
  - February 7, 2017
  - March 7, 2017
  - April 23, 2017
  - May 24, 2017
  - July 24, 2017
  - October 26, 2017

In the meetings,

Because the stories and memories about the local creatures and nature were particularly frequent in the reminiscent talks, we provided the topic of eco-friendly rice fields, and high value-added rice by biodiversity friendly branding, and suggested eco-friendly agricultural channel and farmland in the district.

At a study session conducted during the Iki-iki rice field meetings, branding experts from the beverage company provided guidance on marketing or branding products and some cases of branding strategy for farm goods. Several residents showed interest in cultivating branding high value-added rice in the Shimojin district for community sustainability. In addition to taste and quality, topics as organic or decreased use of chemicals, limpid stream (The Kanayama river which flows across the district), biodiversity, and firefly were discussed as branding components during the meeting. Especially, fireflies were considered as the iconic species of the paddy fields of the Shimojin district by the residents, because a myriad of fireflies danced in the paddy fields in old days. This discussion led to the recollection of sweet memories of firefly watching and catching experiences.

To promote the Shimojin brand rice, we established a new entity called "Mashiki Shimojin Organic Rice Research Study Group," which includes local residents, Kyushu University, and the beverage company. In the study group, every actor plays a different role;

- Local residents practice organic or eco-friendly agriculture and sales in the same branding.
- Kyushu University reports on the effects of eco-friendly agriculture on organisms and taste. Kyushu University also design eco-friendly drainage channel and farmland in the district.
- The beverage company provides indirect support such as proposal of branding image and provision of information on sales channels.

Most importantly, we decided that when branding gets on track and farmers wish to participate in the study group, they will be permitted to do so.

4 Shimojin Branding Rice in Practice

4.1 Design of an Eco-Friendly Agricultural Channel

During the recovery of paddy fields and agricultural channels from the damages caused by earthquakes, we took up measures to improve the environmental conditions of agricultural channels.

From the interviews of local farmers, we identified that the agricultural channels are faced with drought during seasons of non-irrigation (from October to April for the general crop calendar in the district) except for a winter flooded rice paddy field where channels are faced with drought from October to early November when winter flooded rice paddy field starts. This is because customary water right of the district prohibits the intake of river water for irrigation from October to April (or to early

November for winter flooded rice paddy field). The limited amount of river water is allowed for using as antifire water from early November, winter flooded rice paddy field therefore starts in the timing. According to our pre-survey before the environmental improvement, the population of aquatic organisms of the rice fields and the channels in the district was poor and it is considered that the population was heavily impacted by the drought. Another problem of the paddy fields and the channels in the district was the poor connectivity of paddy fields with drainage channels. Steep and long outlets between paddy fields and channels prevent the migration of aquatic organisms such as Dojo loach (*Misgurnus anguillicaudatus*) and Japanese common catfish (*Silurus asotus*). When branding gets on track and eco-friendly agriculture spread in the district in the future, the poor environmental carrying capacity of the channels will become a bottleneck on aquatic biodiversity.

We decided that the objective of the environmental improvement of agricultural channels is to create a permanent aquatic area where common native fish species such as crucian carp (*Carassius auratus langsdorfii*), Dojo loach, and Japanese common catfish can survive through the drought period.

For creating a permanent aquatic area in the channels, small dams were constructed in March 2018. To examine the workability and strength of these structures, they were constructed in three different types using different materials (Figs. 12.4 and 12.5). We initiated the assessment of the impact of these restorations on aquatic organisms. Although the survey had only just begun, some species such as firefly and Dojo loach have been increasing and some goby species colonized at rapid flows created by step structures of the dams.

5 Eco-friendly Farming Method Suitable for the Region

Introduction In this session, we will examine the feasibility of high value-added rice in the Shimojin district, as a means to establish a sustainable Shimojin community. With the aim of the development of high value-added rice having high biodiversity and produced through eco-friendly farming, we practice multiple eco-friendly farming methods and examined the responses of organisms in the paddy field. The ever eco-friendly farming method was assessed by comparing the taste of the harvested rice and its effect on the biodiversity of the paddy field.

Material and Method The location of the paddy field where the examination was conducted is shown in Fig. 12.6. The paddy field is located in the Shimojin District and is adjacent to the Kanayama River, where the spring water from mountains is used as irrigation water and drains into the river. In addition, the outlet releases water from the top edge of a 5-m-high embankment with a gradient of 1/1. Therefore, it is supposed that fishes in the river cannot swim up to the paddy field under study.

In this study, six experimental plots were created in the paddy field, and rice cultivation and biological research were conducted. A schematic diagram of the experimental plot is shown in Fig. 12.7. The experimental plots were created by

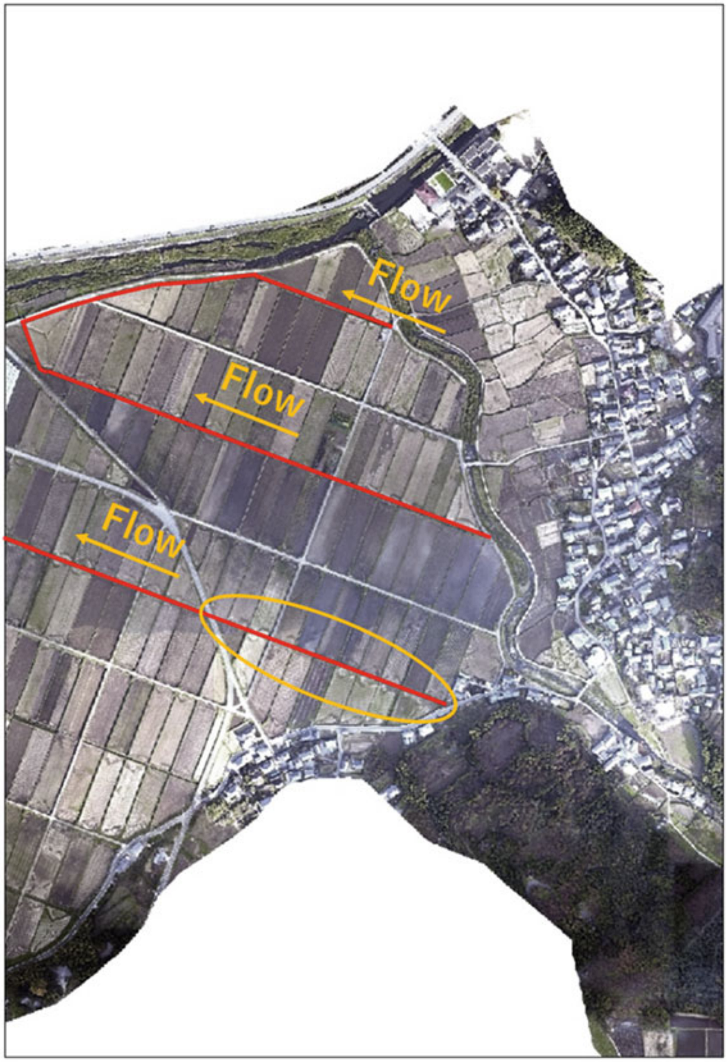

Fig. 12.4 Aerial photo of the Shimojin district. Red lines indicate the main drainage agricultural channels and the orange circle indicates the region where environmental improvement was done

dividing a 5 × 20 m rectangle by a PVC wall having a height of 30 cm. These PVC walls were embedded on the ground at a depth of 10–15 cm to prevent water penetration into neighboring plots. Watergates with a width of 10 cm were installed on both inlet and outlet sides of each plot, and the height of the watergate from the bottom was changed from 3 cm to 20 cm. In addition, we created ridges on the inlet side of each experimental plot so that organisms such as adult frogs can freely come and go (Fig. 12.8).

Fig. 12.5 Resulting structure of dams. Dams create permanent aquatic areas and step-pool structures in the channels. Dams were built using three types of materials. (**a**) Stonework. (**b**) Flashboard. (**c**) Log

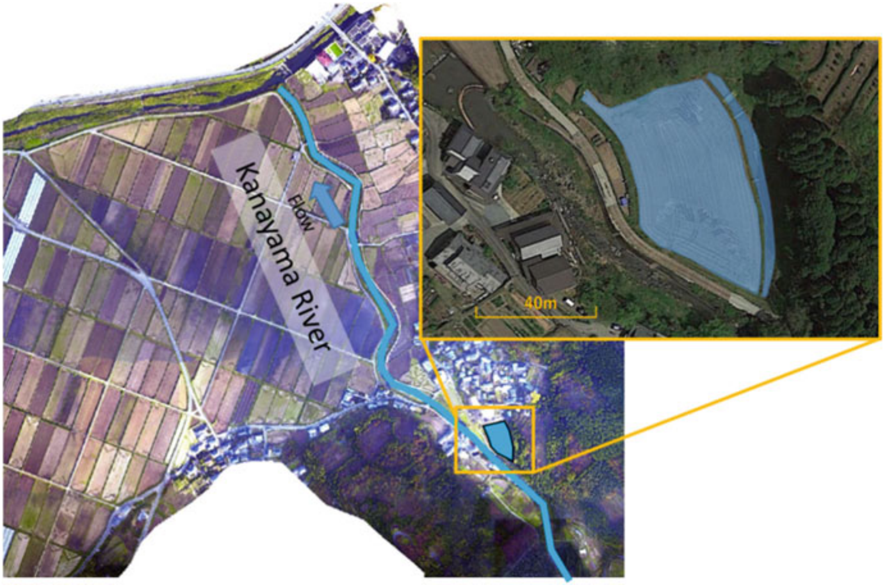

Fig. 12.6 Location of the paddy field where the examination was conducted

As common cultivation conditions of each experimental plot, rice was manually planted at an interval of 21 × 33 cm, and the yield amount was compared after harvest. Rice planting was conducted on June 17, 2017, and Hinohikari (a common variety of rice in Kyushu Island) was used. We did not record the amount of weeding effort and weed mass for each plot, a challenge encountered by farmers practicing eco-friendly farming, because weeds did not grow in the paddy field likely due to weed consumption of golden apple snail (*Pomacea canaliculata*) in the research.

The experiment was conducted based on the following five farming methods and a control plot.

Experimental Plot 1: Conventional Cultivation

In the plot, a farming method based on Hinohikari cultivation generally performed in Kumamoto Prefecture. According to interviews from local farmers

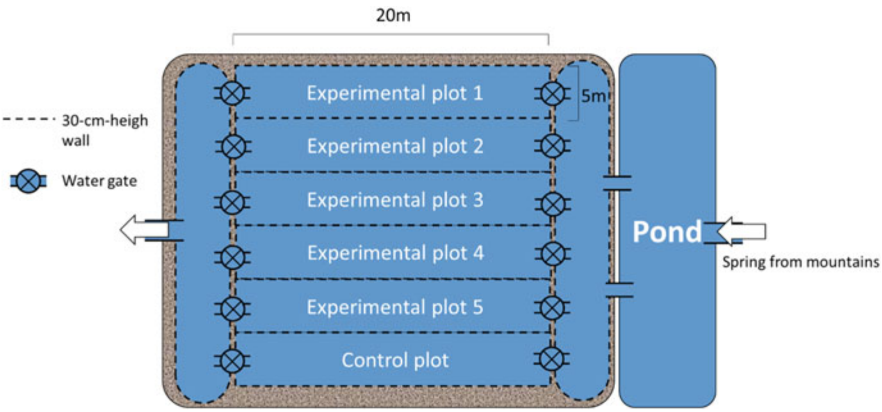

Fig. 12.7 Schematic diagram of the experiment plots

Fig. 12.8 Ridges on the inlet side of each experimental plot

and a crop calendar published by Japan Agricultural Cooperatives Chikuzen (2017), we decided the timing of irrigating, drying, harvesting rice, fertilizing, and pesticide use.

Fertilization:

Rice bran (100 kg/10 a) and chemical fertilizers (nitrogen 1 kg/10 a) were used as a base fertilizer. In addition, another chemical fertilizer (nitrogen 3 kg/10 a) was also used.

Pesticide:

Herbicide and pesticide were used twice at the time of rice planting and midseason drainage.

Experimental Plot 2: Postponed Midseason Drainage

The same numbers and timings of fertilization and agricultural chemical use as plot 1 (conventional cultivation). In plot 2, we delayed the start time of midseason drainage for roughly two weeks. It was started in Toyooka City, Hyogo Prefecture to preserve the foraging sites of oriental white storks by extending the irrigation period between rice planting and midseason drainage which aims to secure sufficient time for larvae of tadpoles and dragonflies to metamorphose (Naito et al. 2011).

Fertilization:

Rice bran (100 kg/10 a) and chemical fertilizer (nitrogen 1 kg/10 a) were used as a base fertilizer. A chemical fertilizer (nitrogen 3 kg/10a) was used as additional fertilizer.

Pesticide:

Herbicide and pesticide were used twice at the time of rice planting and midseason drainage.

Experimental Plot 3: Reduction of Agricultural Chemical Uses

The same water management as conventional cultivation, however the number and amount of agricultural chemical uses were halved compared to that of conventional cultivation of Kumamoto prefecture. A farming method that reduces usage fees compared to (Kumamoto Prefecture 2015).

Fertilization:

Rice bran (100 kg/10 a) was used as a base fertilizer. Rice bran (40 kg/10 a) was also scattered at the time of rice planting as a fertilizer and an herbicide. Chemical fertilizer (nitrogen 3 kg/10a) was used as additional fertilizer.

Pesticide:

A chemical herbicide was used at the time of rice planting and a pesticide was used at the time of midseason drainage.

Experimental Plot 4: Organic Cultivation

In the plot, an organic farming method was conducted. Water management and fertilization were decided according to Imasaka (2014) and interviews with local organic farmers.

Fertilization:

Rice bran was used as a base fertilizer (100 kg/10 a) and an additional fertilizer (40 kg/10a). Rice bran (40 kg/10 a) was also scattered at the time of rice planting as a fertilizer and an herbicide.

Pesticide:

Not used.

Experiment plot 5: Organic cultivation with bamboo chip fertilization

In addition to water management and fertilization similar to organic farming, bamboo chips each of 1.4 mm in thickness were scattered at the time of planting rice. These chips were used for the purpose of weed suppression.

Fertilization:

Rice bran was used as a base fertilizer (100 kg/10 a) and an additional fertilizer (40 kg/10a) was also used. Rice bran (40 kg/10 a) and bamboo chips (280 kg/10 a) were also scattered as a fertilizer and an herbicide, respectively, at the time of rice planting.

Pesticides:

Not used.

Control Plot:

This plot is a control area for bio-assessment where it is filled with water during the rice-growing season, without midseason drainage, fertilizers, pesticides. It was decided that rice will not be planted here.

Aquatic organism surveys were conducted eight times (between 27 June to 28 September) at every experimental plot and the pond that stored the spring water from the mountains. Rice harvested from each plot was tested along with its eating quality using component analysis.

5.1 Result and Discussion

The aquatic organisms collected in the recent study are listed in Table 12.1.

In this survey, two fish species were collected; the fluvial Kawa-yoshinobori (*Rhinogobius flumineus*) and the Dojo loach (*Misgurnus anguillicaudatus*). Dojo loach is known to utilize paddy as its spawning and nursery habitat. The number of juvenile Dojo loach is depicted in Fig. 12.9. These juveniles were collected from all the survey plots including that of the pond. Although adult loaches were collected only from the pond, all other organisms collected from the paddy survey plots were therefore juveniles.

Although the juveniles of the loach were collected until the June 20 survey in the six experimental plot and the control plot, the population of the loach juvenile started increasing from 30 June survey (Fig. 12.9).

Tanaka (1999) conducted a survey of the loach population in paddy fields, temporary creeks, and permanent creeks in Matsuyama city, Ehime Prefecture, and found that the loaches hatched and grew in the paddy fields migrated into neighbor creeks around midseason drainage, which is consistent with the results of this study. It is supposed that the loach juveniles in the paddy plots migrate to the pond or Kanayama River via an outlet.

In contrast, Tanaka (1999) found that a part of the loach juveniles burrow into the soil during the midseason drainage period and endure drying, and the population of loaches in paddy fields population increased slightly after midseason drainage.

In this study, the recovery of the loach population could not be found in the paddy field after midseason drainage. When the water levels were decreasing in experimental plots 1 and 3 for midseason drainage on July 14, the loaches gathered to form

Table 12.1 Aquatic organisms collected in the recent study

Class	Order	Family	Species
Actinopterygii	Perciformes	Gobiidae	*Rhinogobius flumineus*
	Cypriniformes	Cobitidae	*Misgurnus anguillicaudatus*
Amphibia	Anura	Hylidae	*Hyla japonica* (larvae)
		Ranidae	*Fejervarya kawamurai* (larvae)
			Rana rugosa (larvae)
			Rana nigromaculata (larvae)
Insecta	Diptera	Chironomidae	*Chironomidae* spp. (larvae)
	Hemiptera	Gerridae	*Aquarius paludum*
			Aquarius elongatus
			Aquarius spp. (larvae)
			Gerris lacustris
		Veliidae	*Veliidae* spp.
		Nepidae	*Ranatra chinensis*
			Ranatra unicolor
		Notonectidae	*Notonecta triguttata*
			Anisops ogasawarensis
		Corixidae	*Corixidae* spp.
	Coleoptera	Dytiscidae	*Hydroglyphus japonicus*
			Cybister tripunctatus lateralis
			Cybister tripunctatus lateralis (larvae)
			Eretes griseus
			Dytiscidae spp. (larvae)
		Hydrophilidae	*Sternolophus rufipes*
			Sternolophus rufipes (larvae)
			Amphiops mater
			Berosus lewisius
			Enochrus subsignatus
			Enochrus simulans
			Coelostoma stultum
			Hydrophilidae spp. (larvae)
	Odonata	Libelluidae	*Pantala flavescens* (larvae)
			Orthetrum albistylum speciosum (larvae)
			Libelluidae spp. (larvae)
		Baetoidea	*Baetoidea* spp. (larvae)
Malacostraca	Decapoda	Atyidae	*Atyidae* spp. (larvae)
Branchiopoda	Anostraca	Chirocephalidae	*Branchinella kugenumaensis*
Gastropoda	Architaenioglossa	Ampullariidae	*Pomacea canaliculata*
	Sorbeoconcha	Pleuroceridae	*Semisulcospira libertina*
Bivalvia	Veneroida	Spheridae	*Sphaerium japonicum*

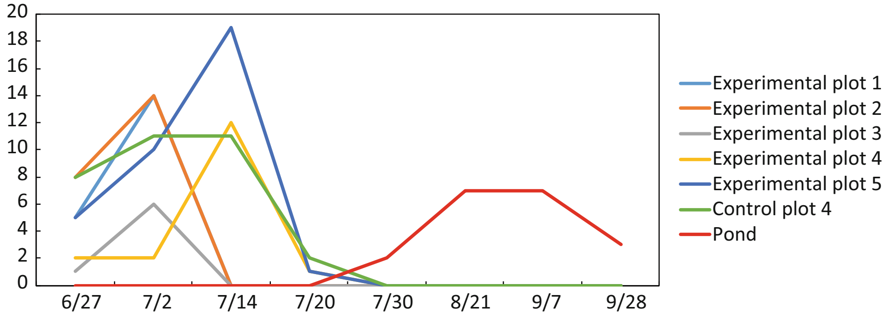

Fig. 12.9 Population of juvenile Dojo loach at each survey plot

Fig. 12.10 Dojo loaches gathered to form loach balls (Dojo Dama)

loach balls (Dojo Dama) before burrowing underground, a behavior known to maintain moisture as long as possible in dry soil (Fig. 12.10). However, in the subsequent survey on July 20, no loaches were found under the soil where they were forming loach balls. It was presumed that these loaches that remained in the paddy field after midseason drainage could not endure dryness or high temperature.

In the experimental plot 6, despite the water being permanently filled, the loach was no longer captured after 7/20. We assumed that this was due to the fact that there was no sunlight shielding such as rice stalks and water temperature became too high for the loaches to survive. The possibility that water temperature has risen around this period is also supported by the fact that the number of loaches collected in the other experimental sections 2, 4, and 5, similarly decreased in the survey conducted on July 20 and 30.

Kawa-Yoshinobori was collected only in the pond. Because the temperature in the paddy field is too high for the inhabitation of goby, which thrives on flowing water environment such as a large river. In fact, a dead goby was found on a plot of paddy field during the survey conducted on July 14. It is presumed that the goby moved into the paddy field due to the heavy rain just before the survey and therefore could not return to the pond.

The black-spotted pond frog (*Rana nigromaculata*) generally spawns in early June in central Kyushu, and the larva of the frog approximately two months to metamorphose. In the southern part of Japan, the delay of irrigation and the shorten period from irrigation to midseason drainage in modern rice cultivation comparing with traditional cultivations inhibit the metamorphose of the larva and impact the distribution of the frog (Murakami and Osawa 2008). In the present study, the eggs of the frog were found at the time of planting rice, and tadpoles were collected in subsequent surveys until July 20. After July 20, no tadpoles or juvenile frogs were found, and therefore, it was supposed that all the tadpoles metamorphosed and migrated to mountainous areas. The larvae of the tree frog (*Hyla japonica*) started metamorphosing and getting onshore from July 14. The larvae of the Indian rice frog (*Fejervarya kawamurai*) started metamorphosing and getting onshore from July 20. The general start time of midseason drainage in conventional cultivation in the region is in the middle of July, therefore, it is considered effective to delay the drainage time a little more to conserve the three species.

In experimental plot 6 (control zone), where there was an open water surface, relatively greater number of water strider (*Aquarius paludum*) was recorded as compared with the other plots. Whereas, it was found that a relatively small number of plant beetles was collected. These plant beetles were collected right after the rice planting was performed in the experimental plots 4 and 5, which are organic paddy fields. The plant beetles may have been attracted by rice brans or bamboo chips in these organic paddy fields.

Regarding dragonflies, larvae of the globe skimmer (*Pantala flavescens*) and the white-tailed skimmer (*Orthetrum albistylum*). All were only organic paddy fields in the experimental plot 4 and 5 and experimental plot 6 (control zone). Previous study has suggested that dragonfly larvae are vulnerable to pesticides (Nakanishi et al. 2009), and it supports the result of our study.

Table 12.2 Yield of each survey plot

Experimental plot	Fertilizer used at rice planting	Additional fertilizer	Yield (kg/10a)
Experimental plot 1	Chemical	Chemical	425
Experimental plot 2	Chemical	Chemical	418
Experimental plot 3	Organic (rice bran)	Chemical	390
Experimental plot 4	Organic (rice bran)	Organic (rice bran)	382
Experimental plot 5	Organic (rice bran)	Organic (rice bran)	384

The yields of each experimental plot are presented in Table 12.2. A yield of around 420 kg/10a was obtained in the conventional cultivation plot (plot 1), and postponed midseason drainage paddy field (plot 2), while the yield is reduced to 380–390 kg/10a in the reduced agricultural chemicals plot (plot 3), organic cultivation (plot 4) and organic cultivation with bamboo chip fertilization (plot 5). The difference in yield between conventional cultivation and organic cultivation was about 10%, which was in general agreement with previous reports (Asai et al. 2016). It was suggested that in all the agricultural methods using rice bran at the timing of rice planting, the yield decreased compared to conventional cultivation. Rice bran was sprayed for the purpose of suppressing weeds, which may affect not only weeds but also rice. In some cases of biodiversity conservation branding rice in other areas, the market prices are more than twice that of conventional rice (for example, Toki funjatta Mai). A loss of approximately 10% in yield can be covered by high added value.

Table 12.3 presents the results of eating quality analysis conducted by Satake Co., Ltd. Based on the results, it was determined that Hinohikari in Kumamoto city had the highest eating quality. From the viewpoint of ingredients, the rice harvested in this study was overdried and the protein intake was higher in Hinohikari in Kumamoto city. In general, amylose is known to depend on rice varieties and the temperature condition in the ripening period. As a cultivation method aimed at reducing the protein content of rice, deep water management, or midseason drainage at the time of secondary tiller, and non-use of the excessive amount of additional fertilization are crucial (Matsunami et al. 2016). In this study, it is considered that there was no problem associated with water management of each plot because deep water management was conducted in experimental plot 2 and midseason drainage in other experimental plots in late July, which is the time of secondary tiller. As for the additional fertilization, the amount of nitrogen 3 kg/10 was decided based on the interviews conducted with the local farmers and a crop calendar published by JA Chikuzen Asakura. However, we did not base it on the soil fertility diagnosis. The overuse of fertilizers could have led to decreased eating quality.

Table 12.3 Result of eating quality analysis

	Experimental plot 1	Experimental plot 2	Experimental plot 3	Experimental plot 4	Experimental plot 5	Hinohikari from Kumamoto City
Eating quality score	66	59	60	66	61	72
Protein (%)	7.9	8.8	8.6	7.7	8.3	7.3
Wet (%)	11.4	11.4	11.0	10.9	12.0	13.8
Amylose (%)	19.9	20.5	20.4	19.8	20.4	19.3

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