Natural Resources Conservation and Research (2019) Volume 2
doi:10.24294/nrcr.v2i2.498

Conservation of Aquatic Animals Inhabiting Low-lying Plains and Mountainous Regions in Japanese Rural Areas

Akira Matsui

Keifuku Consultant Co., Ltd., Japan

ABSTRACT

The purpose of this study was to consider the present status and challenges of aquatic animals inhabiting low-lying plains and mountainous regions in Japanese rural areas and to propose future conservation measures. My conclusions are as follows. On low-lying plains where modernizing agriculture such as farmland consolidation is developed, the development project is pointed out the problems from the viewpoint of the conservation of aquatic animals. My preference is for the irrigation water system to be pipelined and the drainage water system to be open channel. As for the drainage network, year-round water flow and the use of natural materials for canal beds are very important. Mountainous regions have suffered from depopulation, and maintaining terrace paddy fields has been difficult. To use agriculture to fulfill multiple functions, I propose zoning into agricultural land management areas, grass and forest management areas, and native forest areas. Appropriate adaptive management is required both on low-lying plains and mountainous regions. Additionally, it is significant to conserve aquatic animals in the watershed. The components of the watershed include farm ponds, dam reservoirs, lakes, flood control basins, paddy fields, rice terraces, rivers, irrigation canals, and drainage canals. It is also important to ensure water flow in the artificial systems around the paddy fields throughout the year. Using springs and groundwater during non-irrigation seasons is effective and efficient both on low-lying plains and in mountainous regions.

***Keywords*:** Depopulation; Farmland Consolidation; Multiple Functions of Agriculture; Watershed

1. Introduction

Agriculture can have significant impacts, both negative and positive, on the environment. Negative impacts include pollution and degradation of the soil, water, and air. Agriculture can also benefit the ecosystem, such as by trapping greenhouse gases within crops and soils or mitigating flood risks through the adoption of certain farming practices (OECD Homepage). Japan is one of the OECD countries that have succeeded in modernizing agriculture in monsoon areas.

Paddy fields in Japanese rural areas are mainly located on low-lying plains, while terrace paddy fields are situated in mountainous regions. The functions of paddy fields are not only food production but also the conservation of biodiversity, culture, and landscape. In general, paddy fields located on low-lying plains account for most of the area's rice production, in contrast to those situated in mountainous regions, which are largely areas in which the conservation of biodiversity, culture, and landscape is prioritized. That is to say, the agricultural practices pursued in Japanese rural areas have multiple functions.

Small farms are "multi-functional" and tend to be more productive, more efficient, and contribute more to economic development than large farms (Rosset 1999). Family farming preserves traditional food products while contributing to a balanced diet and safeguarding the world's agro-biodiversity and the sustainable use of natural resources (FAO Homepage).

The problems on low-lying plains and in mountainous regions are as follows. Conventional paddy farmland consolidation on low-lying plains, which aims to increase farming efficiency by improving the drainage conditions of

doi: 10.24294/nrcr.v2i2.498

paddy fields and independently creating irrigation and drainage canals, is thought to have negative impacts on biodiversity in Japanese rural areas. On the other hand, mountainous regions suffer from depopulation, and maintaining terrace paddy fields has been difficult.

This study aims to consider the present status and challenges of aquatic animals inhabiting low-lying plains and mountainous regions in Japanese rural areas and to propose future conservation measures.

1.1 Zoning of Japanese rural areas

Japanese rural areas are divided into low-lying plains and mountainous regions. Low-lying plains are separated into urbanized areas and plain rural areas, and the mountainous regions are zoned into agricultural land management areas, grass and forest management areas, and native forest areas (**Figure 1**).

The modernization of agricultural lands is actively promoted on low-lying plains because farmland consolidation is easy to carry out there, whereas in mountainous regions there are many slopes, so the farmland consolidation has been delayed in combination with depopulation and the aging of the farmer population.

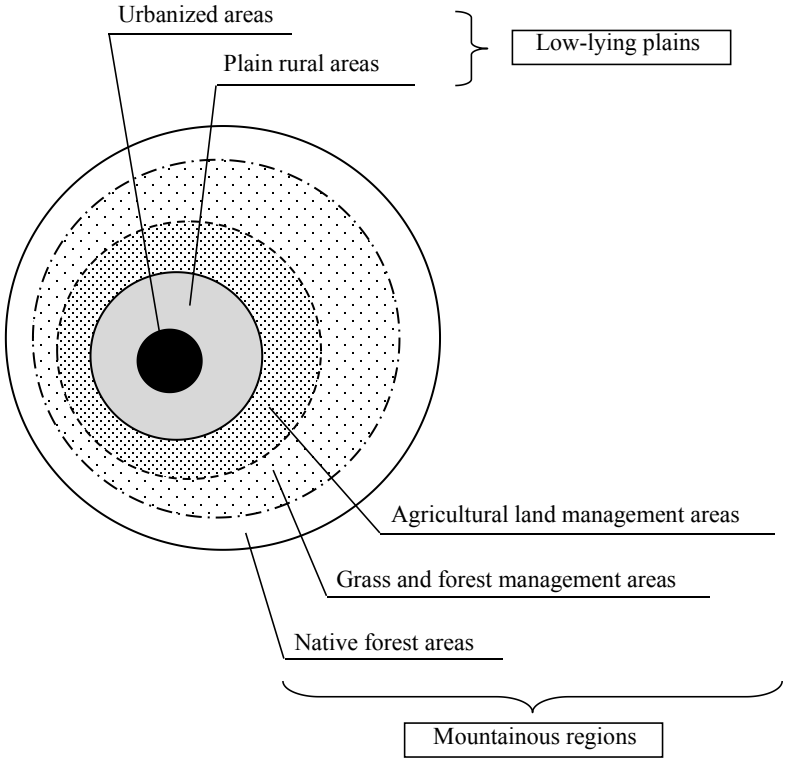

Figure 1; Zoning of Japanese rural areas**.**

2. Present status and challenges of aquatic animals inhabiting Japanese rural areas

2.1 Low-lying plains

As flat terrain is abundant on low-lying plains, modernized agricultural methods such as farmland consolidation are practiced there. Such modernized agriculture results in large increases in rice productivity. However, conventional agricultural infrastructure improvement and rural development projects are pointed out the problems from the viewpoint of conservation of aquatic animals.

For example, aquatic animals do not move by separating irrigation and drainage canals, and their habitat is destroyed when the water flow in the canals dries up during non-irrigation seasons (Hata 1997). The status of Rana species has been adversely affected by the conversion of rice fields to the new irrigation system. Modification of the deep, U-shaped concrete ditches and the water management regime during the spawning season is needed to safeguard

these species (Fujioka and Lane 1997). Traditionally rice Oryza sativa fields in Japan are irrigated by diverting river water through shallow earth ditches using sluices and weirs. However, this 'old-style' method is being replaced rapidly by a 'new-style' system in which water is pumped into paddy fields via taps and drained into deep concrete-sided canals. Concern has been expressed that the changes may cause paddy fields to decline in value as foraging habitats for egrets and herons, Ardeidae, because their aquatic prey are unable to move easily into new-style fields (Lane and Fujioka 1998). The abundance and diversity of fish differ significantly depending on whether the irrigation ditches used to supply and discharge water are the same or not. The rice fields were classified into three types: Type 1 fields, which are terraced and supplied with water from an upper pond; type 2 fields, which are supplied with water from drainage ditches; and type 3 fields, which are supplied and drained by separate irrigation ditches. The abundance and diversity of fish did not differ significantly between types 1 and 2, but they were extremely poor in type 3. The recent rearrangement of rice fields from types 1 and 2 to type 3 evidently reduced fish abundance and diversity (Katano *et al*. 2001). From the above, it is understood that conventional agricultural infrastructure improvement and rural development projects destroy the habitats of aquatic animals.

On the other hand, even if the paddy fields are consolidated, many aquatic animals make their habitat on low-lying plains as follows. The drainage systems in the consolidated paddy fields are clearly composed of different levels of drains with peculiar physical conditions, e.g., water depth and flow velocity, each of which attracts certain aquatic animals. Thus, various living spaces are created by paddy farmland consolidation (Matsui and Satoh 2004a). The 10 species of fishes caught in the irrigation and drainage canals of the consolidated paddy fields can be classified into two groups: fishes living mainly in drainage canals, such as *Misgurnus anguillicaudatus* and *Silurus asotus*, and those living both in irrigation and drainage canals, such as *Gnathopogon elongatus elongatus* (Matsui and Satoh 2004b). Indeed, remarkable agricultural infrastructure improvements and rural development projects which are done to increase rice productivity adversely affect the aquatic animals that inhabit paddy fields. However, high rice productivity and biological conservation can be compatible if special care is taken to protect aquatic animals.

2.2 Mountainous regions

As slope areas abound in mountainous regions, the modernization of agriculture there has been slow to develop. No agricultural modernization has been done to contribute to the conservation of biodiversity, culture, and landscape. Therefore, many aquatic insects utilize paddy fields and farm ponds as their habitats and breeding grounds in mountainous regions (Hibi *et al*. 1998; Saijou 2001).

On the other hand, maintaining paddy fields and farm ponds has been difficult because of depopulation. The area of abandoned farmland has increased, therefore the multiple functions of agriculture are no longer fulfilled. As the area of abandoned farmland has increased, the runoff has become higher and sharper (Yoshida *et al*. 2012; Yoshimura *et al*. 2001). Agricultural land consolidation is important to induce structural changes in the soil and to reduce erosion events on mountainous paddy fields (Mihara 1996). Both land abandonment and agricultural intensification appear to asymmetrically decrease the habitats of rarer herb species in semi-natural grasslands (Uematsu *et al*. 2010). The above findings suggest that moderate management by farm land consolidation in mountainous regions contributes to the conservation of biodiversity and helps prevent disasters.

3. Conservation measures for aquatic animals inhabiting Japanese rural areas

3.1 Low-lying plains

The River Act of Japan was amended in 1997 to improve and conserve the river environment. In addition, the Land Improvement Act of Japan was passed in 2001 and requires agricultural and rural development projects to be harmonized with the environment. It is widely recognized that transforming concrete irrigation and drainage canals into earthen canals and minimizing the differences in elevation between paddy plots and drainage canals aid in the preservation of aquatic animals. However, most paddy fields that have been consolidated using conventional standards

will inevitably remain intact, and thus will continue to have a substantial influence on the regional environment. Therefore, at least minimum environmental measures should be effectively implemented in consolidated paddy fields.

In consolidated paddy fields, irrigation and drainage canals are divided; furthermore, irrigation canals are divided into main canals, lateral canals, and farm ditches, and the drainage canals are also divided into main drains, lateral drains, and farm drains. It is likely that aquatic animals choose their habitats in these canals depending on the aptitude of each species. The volume of water that is contributed to the environment and paddy field ecosystem is extremely limited. Therefore, in order to run flowing water in non-irrigation seasons, and to connect the drainage canals to the irrigation canals in a way that is both effective and efficient, the technical problems of where to run the flowing water must be solved.

Generally speaking, it is difficult to adopt the viewpoint of conservation of aquatic animals in the irrigation canal in comparison with the drainage canal because a concrete canal is used on three sides to supply water effectively and efficiently, and there is no water flow in the irrigation canal in non-irrigation seasons. Hata (1997) points out that it is desirable to maintain a consistent habitat in both the irrigation and drainage networks, although in general it is realistic to target the drainage network.

Therefore, I propose that the irrigation water system to be pipelined and the drainage water system to be open channel. As for the drainage water system, I suggest that year-round water flow and the use of natural materials for canal beds are very important (Matsui and Satoh 2004a).

3.2 Mountainous regions

Agricultural land resource maintenance by extensive management has been proposed (Arita *et al*. 2000; Arita 2005). Abandoned rice fields in mountainous regions ultimately transit to forest (Iwata and Narioka 2002). Egaitsu and Syougengi (1995) classified mountainous regions into four categories depending on their agricultural production conditions and their access to the city. I classify the areas in mountainous regions into three types: agricultural land management areas, grass and forest management areas, and native forest areas (**Table 1**). The positions of the three areas are as shown in **Figure 1**. In fact, it is important that the mountainous regions are lively by giving up on the utilization of abandoned farmland in native forest areas. Since abandoned farmland has more biodiversity than cultivated farmland, appropriate and adaptive management is required. This also applies to low-lying plains. As Japan will have a declining population in the future, it is important to clearly separate managed farmland from farmland that is not managed.

		Access to the city	
		Good	Bad
Agricultural production conditions	Good	Agricultural land management areas	Grass and forest management areas
	Bad	Grass and forest management areas	Native forest areas

Table 1. Zoning plan in mountainous regions

4. Conservation measures for aquatic animals from the viewpoint of the watershed

I therefore conclude that it is necessary to institute minimal environmental measures on low-lying plains and to perform careful zoning in mountainous regions in Japanese rural areas (**Table 2**). Appropriate and adaptive management is required both on low-lying plains and in mountainous regions.

Additionally, when considering the conservation of aquatic animals both on low-lying plains and in mountainous regions, it is important to take the watershed into consideration. The components of the watershed include farm ponds,

dam reservoirs, lakes, flood control basins, paddy fields, rice terraces, rivers, irrigation canals, and drainage canals (**Figure 2**). It is important to ensure water flow in the artificial systems around the paddy fields throughout the year. To do so, using springs and groundwater in non-irrigation seasons is effective and efficient both on low-lying plains and in mountainous regions. However, since the available amount of spring water is decreasing due to the excessive use of groundwater in winter (Matsui 2011), it is important not to use too much groundwater or spring water.

	Present status	Conservation measures
Low-lying plains	Modernizing agriculture by farmland consolidation	To institute minimal environmental measures such as year-round water flow
Mountainous regions	Depopulation and abandoned farmland	Zoning into agricultural land management areas, grass and forest management areas, and native forest areas

Table 2. Present status and conservation measures both on low-lying plains and in mountainous regions

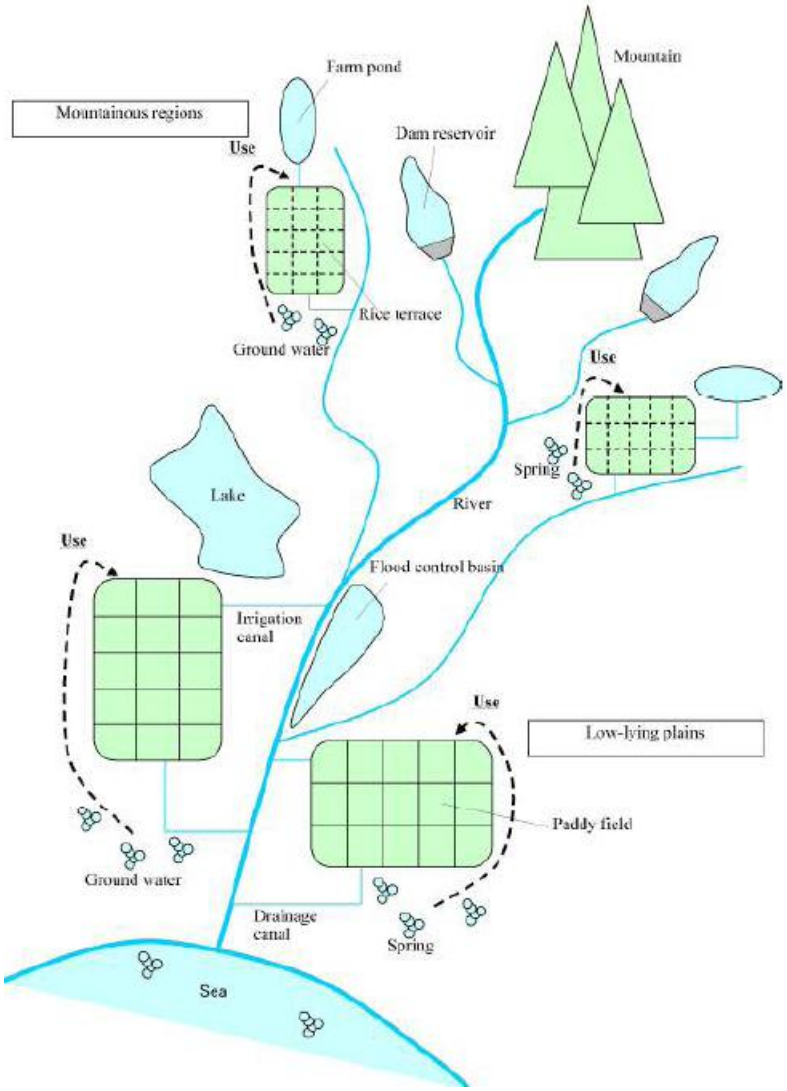

Figure 2; Component of the watershed in Japanese rural areas**.**

Conflict of Interest

No conflict of interest was reported by the author.

References

1. Arita H, Tomosyou T, Kawahara H. Agricultural land resource maintenance by extensive management (in Japanese with English Abstract). Transactions of the Japanese Society of Irrigation, Drainage and Reclamation Engineering 2000; 209: 707-715.
2. Arita H. Abandoned paddy field management: Functions of cattle grazing and land use (in Japanese with English Abstract). Transactions of the Japanese Society of Irrigation, Drainage and Reclamation Engineering 2005; 235: 51-58.
3. Egaitsu F, Syougengi S. Be big-hearted, Japanese agricultural new logic (in Japanese). IE-NO-HIKARI ASSOCIATION, Tokyo, 1995.
4. FAO homepage: http://www.fao.org/family-farming-2014/en/ Accessed 25 January 2018.
5. Fujioka M, Lane SJ. The impact of changing irrigation practices in rice fields on frog populations of the Kanto Plain, central Japan. Ecological Research 1997; 12: 101-108.
6. Hata K. Improvement methods of agricultural irrigation and drainage facilities in consideration of biota conservation (in Japanese). Advice Center for Rural Environment Support, Tokyo, 1997; 22-25.
7. Hibi N, Yamamoto T, Yuma M. Life of aquatic insects in artificial system around paddy field (in Japanese). In: Ezaki Y, Tanaka T (ed.), Conservation of waterfront environment - View point of biotic community, Asakura Publishing Co., Ltd., Tokyo, 1998; pp. 111-124.
8. Iwata F, Narioka H. Change of soil structure and plant succession of renounced rice field in hilled rural area (in Japanese). Journal of the Japanese Society of Irrigation, Drainage and Reclamation Engineering 2002; 70: 207-210.
9. Katano O, Hosoya K, Iguchi K, *et al*. Comparison of fish fauna among three types of rice fields in the Chikuma River basin, Japan (in Japanese with English Abstract). Japanese Journal of Ichthyology 2001; 48: 19-25.
10. Lane SJ, Fujioka M. The impact of changes in irrigation practices on the distribution of foraging egrets and herons (Ardeidae) in the rice fields of central Japan. Biological Conservation 1998; 83: 221-230.
11. Matsui A. Seasonal change in spring discharge of Unjou water and Tsushima's famous water, Obama City, Fukui Prefecture, Japan (in Japanese with English Abstract). Ecology and Civil Engineering 2011; 13: 165-169.
12. Matsui A, Satoh M. Distribution of aquatic animals in the drainage systems created by paddy farmland consolidation in Shimodate City, Ibaraki Prefecture, Japan (in Japanese with English Abstract). Japanese Journal of Conservation Ecology 2004a; 9: 153-163.
13. Matsui A, Satoh M. A proposal for fish habitat improvement based on the analysis of fish distribution in the irrigation and drainage systems of a consolidated paddy field (in Japanese with English Abstract). Ecology and Civil Engineering 2004b; 7: 25-36.
14. Mihara M. Effects of agricultural land consolidation on erosion processes in semi-mountainous paddy fields of Japan. Journal of Agricultural Engineering Research 1996; 64: 237–247.
15. OECD homepage: http://www.oecd.org/tad/sustainable-agriculture/agri-environmentalindicators.htm Accessed 25 January 2018.
16. Rosset Peter M. The multiple functions and benefits of small farm agriculture in the context of global trade negotiations. The institute for food and development policy, 1999; 1-22.
17. Saijou H. Seasonal prevalence and migration of aquatic insects in paddies and an irrigation pond in Shimane Prefecture (in Japanese with English Abstract). Japanese Journal of Ecology 2001; 51: 1-11.
18. Uematsu Y, Koga T, Mitsuhashi H, *et al*. Abandonment and intensified use of agricultural land decrease habitats of rare herbs in semi-natural grasslands. Agriculture, Ecosystems & Environment 2010; 135: 304–309.
19. Yoshida T, Masumoto T, Horikawa N. Changes in rainfall-runoff characteristic of small watersheds due to cultivation conditions of hilly paddies (in Japanese with English Abstract). Irrigation, Drainage and Rural Engineering Journal 2012; 278: 117-124.
20. Yoshimura A, Ishida K, Tokashiki M. The effect of abandoned paddy fields on run off characteristics in small mountainous basins (in Japanese with English Abstract). Transactions of rural planning 2001; 3: 139-144.