

Efforts to improve biodiversity in paddy field ecosystem of South Korea

* Jae Ok Kim¹, Seung Heon Lee¹ and Kyu Sang Jang¹

Abstract Paddy fields have worked as a nursery of biodiversity and cultural diversity. Moreover, paddy fields have provided multiple functions like flood control, ground-water recharge, preventing soil loss, and water purification. The 10th Ramsar convention was a good chance to appeal recognitions of useful benefits of paddy fields. At that meeting, this resolution declared that the paddy fields offer unique habitats for living things. However, environment of paddy fields in Korea has been changed by the economic development, urbanization and increase of rice supply. Thus it is necessary to have stronger efforts to improve and protect the paddy field ecosystem. In this paper, we would like to introduce the current status of Korean agriculture and environmental change in paddy fields by economic development. We suggest some suitable methods for improving biodiversity in Korean agricultural environment.

Key words Paddy field ecosystem, Biodiversity, Fish-way, Small pool, Habitats

Introduction

Rice has been cultivated as a major source of food in 114 countries and all the continents (KRC 2001). Although paddy fields were originally wetlands and artificially constructed devices for rice production, they have worked as a nursery of biodiversity and cultural diversity (Kim et al. 2001). This is from the fact that paddies support important wetland biodiversity such as fish, amphibians, and insects (Fig. 1).

Moreover, multiple functions of paddy fields have been recognized including water cycle control (flood prevention, ground water recharge, prevention of soil erosion, sediment collapse and landslides) and environment load

control (water purification, climate mitigation, and organic waste processing) (Lee 2001). But the environment of paddy fields has been changed to increase rice supply as consequences of the economic development and urbanizing (MIFAFF 2010). According to the report by the Korea Rural Community Corporation, rice cultivated areas decreased from 124,400 ha in 1990 to 95,000 ha in 2007 (Fig. 2). Until the large areas of paddy fields have been converted to house, building and road. As a result of these changes, biodiversity grown in the rice field has greatly decreased. The 10th Conference Meeting of the Contracting Parties to the Convention on Wetlands was held in Korea, 2008.

One of the adopted resolutions proposed at this meeting was to regard paddy fields as a wetland. The resolution gives recall and recognition of importance of paddy field

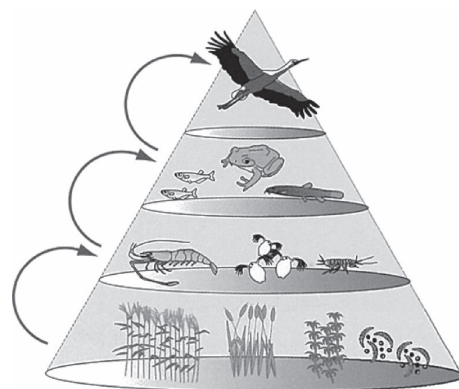


Fig. 1. Pyramid of paddy field ecosystem.

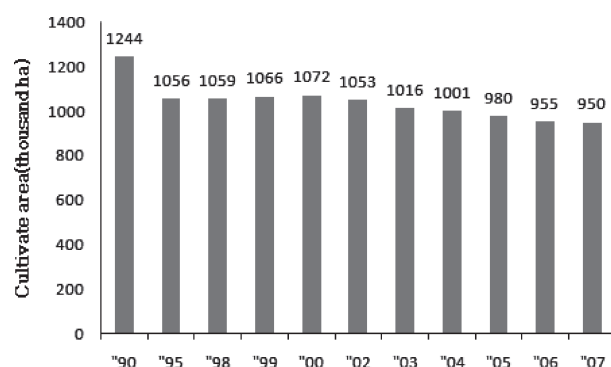


Fig. 2. Yearly variation of rice cultivate area in Korea.

¹ Rural Research Institute of Korea Rural Community Corporation: #391, Hae-an-ro, Sangrok-gu, Ansan-si, Gyeonggi-do 426-908, South Korea

* E-mail: kjokim@ekr.or.kr

as a part of wetland to enrich biodiversity.

In Japan several ecological restoration programs including paddy-drainage fishway, winter-flooding, and buffer zone construction have been conducted in various parts of the country. Japanese government has also declared to restore paddy field ecosystem in the agriculture land improvement law.

So, through this approach, Stronger efforts to improve and protect the paddy fields ecosystem are required. In this paper, the current agricultural situation of Korea, especially the current changes of paddy field environments through economical development will be introduced. Finally we propose the recommendations to improve biodiversity in our agricultural environment.

The summary of rice cropland and canal in Korea

Paddy field and cropland area cover 12.0% and 60.4% of the land area in Korea, respectively. Also, total length of irrigation and drainage canal at the agricultural area reaches 183,000 km, which is approximately 2.8 times of

total river length (National and Local) and 5.0 times of small river length in Korea (Hong 2010) (Table 1 and 2). Therefore, irrigation and drainage canals and rice paddy fields are important zones for sustainable ecosystem management in agricultural area.

Importance of paddy field

Why paddy fields are important? Paddy field has various kinds of beneficial functions. The first is a flood control capacity of rice field. The most common natural disaster in Korea is flooding during summer due to the topographic and meteorological characteristics (Lee 2001).

During the rainy season, rice fields store rain water temporarily and the total holding capacity of rainwater in the fields is 18 times of the Soyang Dam, the largest dam in Korea. The most important source of water used daily by man is ground water. Total amount of the holding capacity of underground water at the rice field in Korea is about 5.45 billion tons. It is equivalent to 2.9 times of the available storage capacity of the largest dam in Korea. Rice field also has a function to prevent soil loss. It takes approximately 200 years to create just only 1 cm of topsoil. About 17 million tons of eroded soil are trapped by paddies every year in Korea. Biological mechanisms of the soil and paddies decompose contaminants flow into the paddy field. Through photosynthesis, paddies fix carbon dioxide from the air and emit oxygen. The rice plant is one of the most efficient crops in absorbing carbon dioxide. In summer time, evaporated water from paddy fields cools the atmosphere about 2–3 degree. Paddy fields are home for variety of wildlife such as fishes, birds, invertebrates, amphibians and reptiles (Fig. 3). As stated above, paddy fields have many functions that benefits our

Table 1. The status of the river in Korea (Unit: km).

	Total length	Repair plan	Completed	Completed rate (%)
National River	3,260	3,113	2,986	95.9
Local River	17,595	14,655	12,849	82.6
Small River	35,815	35,815	12,955	36.1
Total	56,670	53,583	28,790	–

<From National Emergency Management Agency, Ref.>

Table 2. Length of irrigation and drainage canals in paddy fields in Korea (Unit: km, 2009).

	Total length	Natural Canal	Structure Canal
Irrigation canal	116,000	62,000 (53.4%)	54,000 (46.6%)
Drainage canal	67,000	51,000 (76.1%)	16,000 (23.9%)

<From Korea Rural Community Corporation, Ref.>

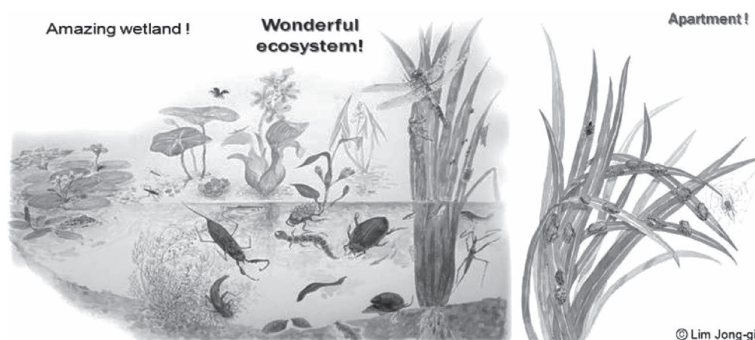


Fig. 3. Paddy field as habitats for various living things.

lives as well as many creatures. So we have to protect and preserve continuously the paddy field ecosystem.

Environmental changes of paddy fields

Many things have changed around paddy fields environment since the outbreak of the war. One of the most several changes is expanded policy of food production. Land consolidation to increase rice production was carried out on a nationwide scale (Fig. 4). This movement facilitated mechanized farming, increased food production and a rise in the agricultural income (Fig. 5). Also, irrigation system changed from natural to structured canal



Fig. 4. Landscape change before (upper) and after (lower) land consolidation (in Gyeonggi province of Korea).



Fig. 5. Landscape change before (left) and after (right) the mechanized farming.



Fig. 6. Change of irrigation system past (upper) and present (lower).

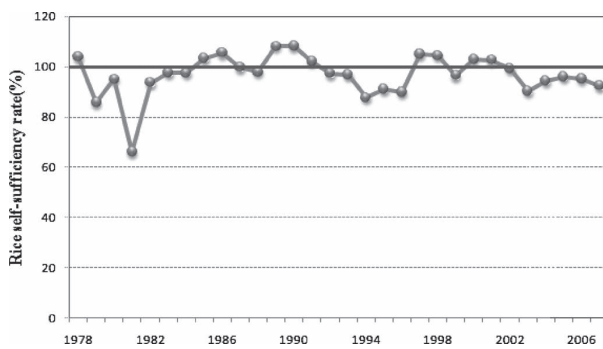


Fig. 7. The trends of rice self-sufficiency rate in Korea (Data source: Korea Rural Economy Institute).

(Fig. 6). In the past, most of rice paddies depended on solely on rainfall for water. But after irrigation system established, rice paddies can obtain sufficient water for agriculture. Consequently, we get the rice self-sufficiency since 1985 roughly (Fig. 7). But, after the development of the paddies biodiversity in paddy fields has decreased seriously. At the ecological pyramid based on the paddies, the most top organisms was oriental white stork and it became extinct in 1974 in Korea. The species richness as well as their abundance of other living things was also affected by changes of paddy infrastructure. We need to pay much attention for biodiversity improvement in paddy fields.

Efforts to improve biodiversity in South Korea

After the 10th Ramsar convention in Changwon, Korea,

several works were started to improve paddy field ecosystems. Importance of rice fields as agricultural wetlands was reflected in global certification from resolution in Ramsar.

○The first challenge is winter-flooding for winter water birds in paddy field (Fig. 8). Paddy fields are habitats of endangered species, especially water birds. Winter-flooded fields are used by water birds including ducks and geese migrating through East Asia-Australia fly-way. The Cheorwon-gun near North Korea is also famous for the wintering sites of migratory birds such as cranes. Winter-flooding is not only beneficial for migratory birds but also for other living things such as invertebrates and, fishes in winter. Therefore we plan to expand the winter-flooding in paddy fields in Korea and start basic research to estimate necessary amount of water to conduct such activities. We hope that people from several areas join winter-flooding program for the sustainable paddy field ecosystem management.

○The second action is to build an eco-bridge like a fish-way that is a structure on or around artificial barriers to facilitate natural migration of fish between paddy fields and drainage canals (Fig. 9). Various types of fishways have been designed and installed already in Japan, but we are still in the preliminary stage for fishway development in Korea. The first fishway was installed in Daeho reclaimed land in Korea, 2010 (Fig. 10). Results obtained from this fishway monitoring revealed that



Fig. 8. Winter-flooded paddy fields in Cheorwon-gun, Korea.



Fig. 9. Landscape of divided canal with paddy field.



Fig. 10. Examples of fishway to connect between paddy field and irrigation canal.



Fig. 11. Small pools next to paddy fields.

various fishes such as rice-fish and mud-fish use it. Many fish used the fishway at dawn of day. We found that this fishway effectively worked to save fish at agriculture area of water shortage.

- The third work is to reinstall small scale pool next to paddy fields (Fig. 11). In the old days, there are many small pools named Dum-bung at a side of paddy fields (Fig. 12) but most of these small pools have disappeared through improvement of irrigation system. Small pools have ecological merits besides irrigation function. During winter and midsummer drainage, small pools play important roles like an oasis to organisms. Hongsung-gun is famous for environment-friendly farming with a long history about 50 years in Korea. These regional farmers voluntarily install small pools to improve ecological environment of paddy fields. There are many living things like fish, invertebrate, amphibians, and reptiles, in small pool (Table 3). Also, throughout the experiment we found that mud-fish moved from paddy fields to the small pool during

Table 3. Invertebrates found in small pool.

Division	Species	Rate (%)
Non-Insecta	17	27.42
Ephemeroptera	1	1.61
Odonata	10	16.13
Hemiptera	10	16.13
Coleoptera	16	25.81
Diptera	8	12.9
Total	34 Families, 62 Species	

the midsummer drainage period. Therefore, small pool plays an important role as shelters for many animals during midsummer drainage period. If farmers are interested in environment-friendly farming, they can install small pools at a low cost. It takes only two hundred and fifty thousand won to establish small pool of 9 square meters. Throughout this investigation we understand that establishing small pool is a good method for improving paddy field ecosystem in Korea.

- The last is to carry out environment-friendly large-scale land consolidation project. For example, various ecological restoration systems were induced with land con-



Fig. 12. Many types small pool at Hongsung-gun, Korea.

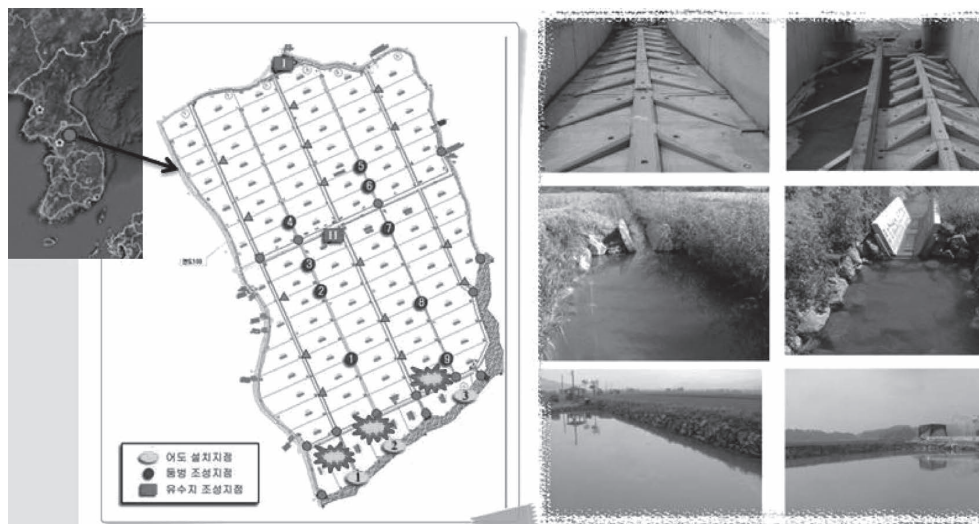


Fig. 13. Environment-friendly readjustment project at Cheorwon-gun, Korea.

solidation at Cheorwon-gun, Korea in 2008. Under a land consolidation project conducted in 52 ha area, fishway was installed in three sites, large scale pool in two sites and small scale pool in nine sites (Fig. 13). Fishways, small and large pools were regularly surveyed for monitoring restoration trend after the end of land consolidation. Unfortunately fishway did not effectively work because of their structure problems. The main problem is that highly seasonal variation of water level of the river. During the low water level period, this fishway cannot work and thus it is needed to repair. In contrast, small and large pool works well and various organisms used those pool throughout the year. Therefore, we concluded that small pools are more efficient approach than fishway for various kinds of living things in land consolidation area. Also ecologists ought to take into account surrounding environment such as water level, agricultural management system, fishes fauna, etc. when installing the fishway.

Conclusions

- Rice has been cultivated in 114 countries around the world. Paddy fields are very important places in various aspects including society, economy, culture and ecology. Therefore, we must preserve our precious paddy field ecosystems.
- Four approaches including winter-flooding, fishway, small pool, and environment-friendly land consolida-

tion can apply immediately in paddies to enrich their biodiversity.

- Paddy fields are important wetlands in monsoon Asia as a habitats of migratory water birds and living creatures. Studies to improve ecological functions of paddy field should be conducted continuously.
- Finally, it is hoped that many scientists can share their results, valuable experiences and problems collected in paddy field ecosystems in Korea.

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