Evaluation of Agri-Environmental Performance of Convention on Biological Diversity Using Winter Paddy Field in Korea

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ABSTRACT: Winter migratory birds gather in paddy rice fields to feed shed rice grains. The Korean Ministry of Environment has practiced a policy program Contract on Paddy Field Management (CPFM) during winter fallow since 2002. This program starts with a contract between local governments and farmers, and the government pays a differential subsidy to farmers who finish spreading rice straw, cultivating barley, letting the whole rice plant without harvest, and submerging paddy fields for winter migratory birds. As more local governments have operated CPFM program, the total area on the contract and subsidy budget has increased yearly since 2002. This program could have its stable position as a successful policy by giving profits to farmers. With the program extended, the population of winter migratory birds has been greatly. For the evaluation of environmental performance of a policy, we analyzed this CPFM program by introducing some indicators in the form of Driving Force-State-Response Framework. The indicators were composed of 3 categorized indicators; the area of paddy land contracted under this program as 'driving force' indicator, population of birds, the number of bird species and the amount of feces as 'state' indicators, and the size of monetary support, the number of farmers or local governments participating, and public perception as 'response' indicators. The contract area of paddy field under CPFM could be a good biodiversity indicator reflecting potential performance of this policy measure in the light of its linkage to the population of winter migratory birds. And the share of CPFM land of the whole agricultural land might also be used as a useful indicator of policy evaluation for improvement of wildlife diversity. The 'state' indicators such as population of birds and the number of bird species could be matched to 'driving force' indicator, but the total CPFM area of each site could not reflect the effect of areas under different management practices. However, the amount of bird feces could reflect differences in environmental performance with management practices as 'state' indicators. The development of indicators indicating 'response' such as farmers' behavior, public perception, and policy makers' willingness is also needed to support a successful implementation and improvement of this policy measure with the development of 'performance' indicators integrating all these indicators.

Key Words: wild species diversity indicator, winter migratory birds, paddy field, agri-environmental policy, environmental performance

INTRODUCTION

There was no attempt for the evaluation of policy measures using agri-environmental indicators in Korea so far. Also, there was no agri-environmental policy

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designed by indicators. Therefore, we tried to evaluate the environmental performance of an on-going environmental policy in the point of view of DSR framework that has been used for analysis and interpretation of cause-result relationships in OECD.

The policy program is about the protection of wild bird species mainly targeting winter migratory birds. So, we made attempts to re-evaluate the effect of the

environmental policy for wildlife migrant protection, so-called Contract on Paddy Field Management (CPFM) using wild species diversity indicators and to seek useful indicators that have not developed in OECD for systematic and effective analysis of a policy. OECD has developed and defined some biodiversity indicators including two wildlife species diversity indicators and three ecosystem diversity indicators as suggested in Environmental Indicators for Agriculture Volume 4[1]. However, in case of biodiversity the development of indicators is not sufficient to describe a variety of characteristics and it also is not easy to define them to the extent that they could be applicable across OECD countries and to interpret changes in biodiversity because a lot of environmental factors are involved in biodiversity with very complex linkages. And, the existing OECD indicators related to biodiversity have a limitation in reflecting changes in environmental performance depending on land management practices driven or supported by policy measures.

Through this approach, we aim to suggest an example of a more systematic evaluation and to find out which indicators have to be further developed and what priority data needed for those are. Also, we want to stress the roles of a biodiversity relating policy and importance of agricultural land use and management practices as a key driving force driven from environmental policies.

Backgrounds for the Introduction of a Convention on Biological Diversity Program

With increasingly growing concerns among the public, systematic survey on the wildlife has been initiated by the Korean National Institute of Environmental Research under the auspice of Korean Ministry of Environment in 1997. Through the nation-wide networks of survey, the Korean National Institute of Environmental Research has observed biannually for hunting animals and wildlife known as environmental indicator animals since then. The networks cover agricultural fields, wetlands, urban area, and forested area including mountainous area and hilly area.

According to the results of the survey[2], species such as Swinhoe's egret, Black Bittern Vag, and Citrin Wagtail Vag were identified to be ones that used farmlands as the main habitat whether they were native or non-native. Most of these birds were found to be dependant on food especially with preference for cereals rather than other environments of nesting and breeding place or shelter. A lot of wildlife including winter migratory birds such as white-fronted goose and whooper swan was fed on rice grains that were scattered over the paddy rice fields during harvest. Paddy rice farming that has been long developed in the Korean peninsula is related to the climatic and topographical features. Paddy fields have provided feeds for a lot of winter migratory birds. In addition to the paddy rice providing cereal feeds, areas that migratory birds visit frequently have other ecological conditions like nesting, breeding and shelter places around paddy fields. Inflow of winter migratory birds during winter was directly related to timing of rice harvest.

As many migratory birds stay in some specific areas having good environmental conditions as their habitats, people have got to have more interests on these areas for the protection of migratory birds. The Korean government has begun to develop various wildlife protection strategies with the international agreement on the Convention on Biological Diversity signed in 1992. One of these efforts was the designation of endangered species and protected areas. As one of more active movements, the Korean Ministry of Environment planned to develop a wildlife migrant protection program so-called the Contract on Paddy Field Management (CPFM) for those areas in cooperation with local governments including non-governmental environmentalists in 1998. This program was also related to the Convention on Biological Diversity and was based on the fact that there was a linkage between the management of paddy fields and attraction of migratory birds. Namely, this program could be supported by a research which established the rationale of this management contract scheme for biological diversity[3]. This CPFM program was to conserve ecological sound agricultural land. Further, the Korean government enacted the Wildlife Protection Act to systematically conserve wildlife species and their habitats in 2004.
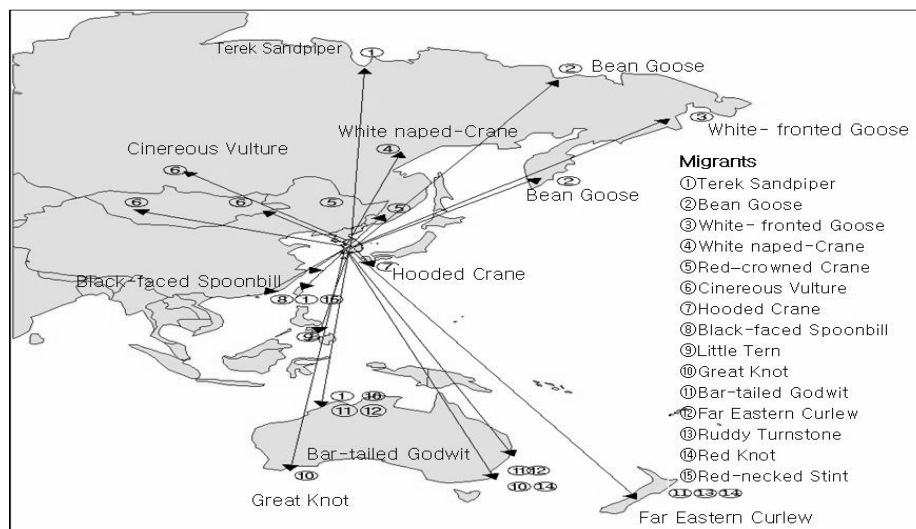
Fig. 1. Migratory routes of bird species around the Korean Peninsula.

Ecological characteristics of migratory birds
Route of winter migratory bird species observed in Korea

Routes for 15 migratory birds observed in Korea are depicted in Fig. 1. Each species has its own specific routes. For example, there are two migratory routes for Hooded crane and White-napped crane; The Amur River of Russia to Izumi city of Japan and Siberia of Russia to the Yangtze River of China.

From the result of recent research on migration routes, it was found that the total number of bird species observed in Primorsky Krai (Russia), North-East China and the Korean peninsula was 538, of which 471 species was observed in Primorsky Krai, 457 species in the North-East China and 423 species on the Korean peninsula, respectively. In eastern Mongolia, a total of 327 bird species have been recorded so far, of which 61 species were year-around residents, 266 species were passage migratory birds and 212 species were breeding species. Species of 407 migratory bird and 55 subspecies have been recorded in North-East three provinces of China, which occupied 34.3% of bird species observed in China[4].

Staying sites of migratory birds on the Korean Peninsula and local areas under CPFM program

For a certain area to function as a habitat for migratory birds, the area should have some basic ecological features for feeding, nesting, breeding and sheltering. From some researches and survey results[5], more than 47 local areas were identified to be a staging area of winter migratory birds in Korea.

Distribution of migratory birds at ecologically different local areas

The Korean National Institute of Environmental Research has surveyed biannually since 1997 for hunting animals and environmental indicator animals at 810 sites from June to July. The institute publishes an annual report on the species and population of birds in the habitats; agricultural fields, wetlands, urban area, mountains, and hills. Species richness of birds was higher in agricultural field compared to the other habitats; 176 species in agricultural field, 144 species in mountains, 148 species in hills, 126 species in wetlands and 97 species in urban area[2].

Agricultural fields had the second top population of birds among the five habitats; 10,868 individuals in mountains, 11,955 in hills, 15,550 in agricultural fields, 2,478 in urban area and 16,794 in wetlands (Fig. 2)[2]. Agricultural fields are rich in food resources, and they are bordering mountains, hills, and streams that provide places for nesting, breeding, and loafing.

Planning and Implementation of the Contract on Paddy Field Management (CPFM)

In many cases, agricultural land is known to be a major primary habitat for many wild species. In Korea, paddy rice farming was found to provide

Fig. 2. Number of wild bird species and individuals of birds observed in the different habitats.

habitats for fish, amphibians and reptile during winter fallow as well as rice cultivation period depending on management practices. Many winter migratory birds including cranes also stay around agricultural lands to feed on rice grains and plant materials such as vegetation and barley plants. To keep paddy fields as habitats for winter migratory birds during winter fallow, the Korean Ministry of Environment enacted CPFM program for paddy fields around famous staging area of migratory birds on the Korean peninsular in 1998.

This CPFM program was based on the results from some preliminary researches and observation over a long time period. Generally, the CPFM program is undertaken through a lot of processes starting from ex ante evaluation to the ex post evaluation to the modification. As the first step to develop a policy or a program, ex ante evaluation is needed.

Land management practices during winter fallow offered as an optional choice of CPFM

The CPFM program was designed to pay a subsidy to farmers implementing agricultural practices that can help feed the wildlife. Four kinds of management practices were recommended for farmers to adopt as an optional choice. These practices noticed officially by local governments were based on attraction effects for a lot of migratory birds from findings of the past researches or observation. These practices were to spread crop residues after harvest such as rice straw over soils in paddy fields, to cultivate barley, to abandon harvesting, and to keep paddy rice fields in a submerged state during winter season. We can see roles of paddy fields as habitats for migratory birds as shown in Fig. 3. Paddy fields can provide feed for different migratory birds during winter depending on

Fig. 3. Practices for winter migratory birds during winter fallow; spreading rice straw (upper left), barley cultivation (upper right), flooding paddy field (lower left), and non-harvesting field (lower right).

the situation of management.

Among local governments, there are differences in optional choices of CPFM as in Table 1. Most of the local government offer 2 or 3 optional choices, and spreading rice straw and barley cultivation were preferred. The reason seems to be derived from various local situations such as socio-economic, farming, and natural environment. For example, in case of not harvesting rice, it takes more money per unit area than in the other cases and plenty of water is required in case of submerging paddy.

Changes in the number of species and population of migratory birds during implementation of CPFM

Yearly change in the number of species and population of wildlife may be an indicator of environmental performance of a policy program although there are many other factors involved therein. According to the reports by the Korean National Institute of Environmental Research[6,7], the number of winter migratory bird species has increased 1.05 times in 2003, 1.19 times in 2004, and 1.27 times 2005 as compared to that in 2002. On the while, the number of bird species was 179 in 2002, 197 in 2003, 185 in 2004, and 182 in 2005 (Fig. 4). This represents that the CPFM would have had an effect on the population and species diversity of winter migratory birds.

Attracting effect for winter migratory birds of different paddy field management under CPFM

The effect of each management practice on the attraction of winter migratory birds can be evaluated by measuring the amount of their feces. There was a great variation in the amount of bird feces among the management practices. Spreading rice straw was the most effective to attract winter migratory birds; the amount of bird feces in the plot with rice straw (138.5 kg/ha) was 1.54 times higher than that in the plot where rice straw was removed (87.8 kg/ha) as shown in Fig. 5. This difference seems to be derived from the difference in many ecological features. Namely, spreading rice straws may supply breeding place for insects that winter migratory feed on preferentially with supply of relatively abundant grains. In addition,

Table 1. Optional choice of CPFM notified officially by local governments in 2005

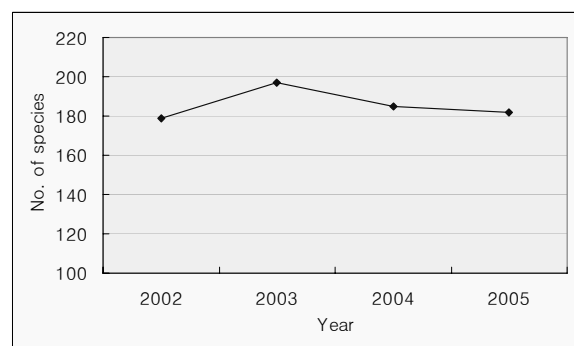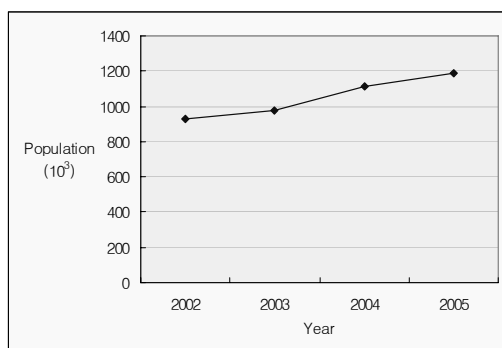| Local government	Spreading rice straw	Barley cultivation	Non-harvest of rice	Submerging paddy
Cherwon	○ (Offer)	x (Not offer)	x	x
Gimpo	○	○	x	x
Seosan	○	○	○	○
Hongseong	○	○	○	○
Kunsan	○	○	x	x
Seocheon	○	○	x	x
Gimje	x	○	x	x
Haenam	x	○	○	○
Suncheon	○	○	○	x
Changwon	○	○	x	x

Fig. 4. Yearly variation in the number of species and individuals of winter migratory birds in Korea.

spreading rice straws is known to have multiple positive effects on the field by supplying soil organic matter sources to increase soil fertility with provision of habitats for insects and microorganism related to soil biodiversity in the paddy field.

On the other hand, tillage cultivation of barley has less effect on attracting migratory birds as compared to that of no-tillage cultivation. This seems to be related to a difference in feed supply of winter paddy fields for winter migratory birds because there are only barley shoot available as feed for them in case of tillage cultivation, whereas there are both barley shoot and shed rice grains in the case of no-tillage direct seeding of barley.

From this result, food richness could be a primary factor to be considered in improving the CPFM program for the protection of winter migratory birds. In addition to this, in order to supply better habitats to the

Fig. 5. Difference in the amount of bird feces depending on paddy field management.

migratory birds, it is desirable that the incentive should be determined on the basis of attracting effect of migratory birds rather than monetary value of labor and cost.

Progress in CPFM

Since three local governments first introduced CPFM program for designated protection areas as pilot sites in 2002, Gunsan, Changwon, and Hanam county, more farmers wanted to participate in CPFM to receive the incentive. So, the total area of paddy fields under CPFM with the increase of local governments introducing CPFM program has greatly increased. In 2006, the total CPFM reached 6,515 ha, which was 28.6 times higher than that in 2002. Total budget has also increased 4.4 times in 2006 as compared to that in 2002 as shown in Table 2[8].

The program was very effective in attracting winter migratory birds and was also different depending on management practices. Farmers were differently paid for their management practices with the respective contract option. This differential subsidy was determined by considering sale price of rice straw and grains, labor, electricity fare, depreciation cost for water pump, and cost for barley seeding; $234 per hector for spreading rice straw, $ 581 for submerging paddy, $3,668 for cultivating barley and $9,035 for non-harvest of rice (Table 3)[8]
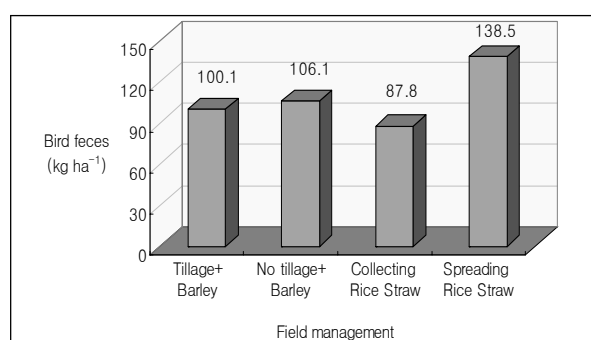
Table 2. Changes in the total area of paddy fields under CPFM and its expenditure

Year	Contracted paddy area (ha)	Budget (Million won, 1,000$)
2002	228	690 (700)
2003	3,540	1,806 (1,843)
2004	4,185	2,370 (2,418)
2005	4,395	2,487 (2,538)
2006	6,515*	3,003 (3,064)

* Tentative CPFM area of 2006

Table 3. Differentially supported payments depending on management practices of paddy lands during winter fallow

Field management	Spreading rice straw	Submerging paddy	Barley cultivation	Non-harvest of rice
Subsidy (US $ per ha)	234	581	3,668	9,035

(* 1$ = 980 won)

Evaluation of the Environmental Performance of the CPFM Program

According to the environmental pathways outlined in the DSR model suggested by OECD works on agri-environmental indicators[9], there are a wide range of economic, social, and environmental factors that influence the environmental outcomes from farming. Even if we exclude the economic and social factors, the environmental outcome from faming or management practices adopted as the results of responses to a certain policy measure could be explained within the DSR framework. However, in the case of biodiversity indicators, it is not easy to define them to the extent that they could be applicable across OECD countries and to interpret changes in biodiversity because a lot of environmental factors are involved in biodiversity with very complex linkages. Biodiversity indicators in Environmental Indicators for Agriculture Volume 4 include two wildlife species diversity indicators[1]. The wildlife species diversity indicators are defined as share of wild species that use agricultural land as primary habitat and populations of a selected group of breeding bird species that are dependant on agricultural land for nesting or breeding. Three ecosystem diversity indicators are defined as conversion of agricultural land area to/from with other uses, area and share of agricultural semi-natural habitats in the total agricultural land area, and share of national important bird habitat areas where intensive agricultural practices are identified as either posing a serious threat or a high impact on the area's ecological function. Biodiversity indicators suggested by OECD are 'driving force' or 'state' indicators. All these indicators do not take land management as one of very important driving forces into consideration and they do not seem to be appropriate in evaluating the performance of CPFM program. So, we tried to seek adequate indicators needed for the interpretation of environmental processes and the evaluation of environmental performance on the basis of observation data obtained in relation to CPFM program for protection of winter migratory birds.

Here, we will look into the applicability and usefulness of indicators established in this study on the evaluation of CPFM program and we will also discuss on challenges for the further development of indicators to make useful ones.

First, we examined the usefulness of DSR framework in the evaluation of environmental performance of a policy measure for biodiversity as in the interpretation of indicators.

In the CPFM program, 4 forms of management practices were suggested to farmers as an option of environmental cross compliance. The management practices might have different effects on attracting wildlife including migratory birds via different pathways even though we could not understand fully possible causes or processes. In this aspect, the area of paddy land subjected to each management practice would function as a 'driving force' indicator. The practices would also have different effects depending on wildlife species. In OECD works on agri-environment indicators, land use has been regarded as one of the most basic driving force in agriculture. The land area has significant meanings as priority data in analyzing environmental issues in agriculture. In addition to land use, input use such as fertilizers, water, and pesticides etc. has been used as core 'driving force' indicator so far. But management practices have not been discussed fully in spite that they are a potentially important factor that can influence the environmental performance. In the CPFM program, management practices of paddy land are the core. Data on the area of paddy land subjected to different management practices can be collected easily because the area will be determined by the contract between farmers and the local governments. But, the land area for each practice is not sufficient to describe environmental performance of a certain policy because of insufficient information on the relationship between practices and their impacts. Therefore, further researches on the relationship between farming or management practices and their impacts will be needed in order to interpret indicators and to link driving force indicators to the analysis of the environmental performance.

In the CPFM program, there was a close link between the population of the wildlife and the size of CPFM land area as we previously mentioned. So, the

CPFM area provided artificially for habitats or feeding places for wild birds could be a good biodiversity indicator indirectly reflecting the performance of a policy measures. And the share of CPFM land of the whole agricultural land might also be used as a good indicator for potential improvement of wildlife diversity.

One of wildlife species diversity indicators was defined as the population of a selected group of bird species in the previous OECD report[10]. This is one of 'state' indicators. By the analysis of data on the population of wild birds observed at each site, there was a relationship between the size of CPFM land area and population of wild birds. So, the population of wild birds could be regarded as one of 'state' indicators that could explain the environmental performance with the enlargement of CPFM land area. But, it is not easy to get data on the population of wild bird species if we do not have an observation network. In many cases, this indicator has some limits actually in tracking a change in the population of wildlife caused by a policy measure. In the CPFM program, it is difficult to get data on the population of wild birds on the land subjected to a specific practice because migratory behavior of birds. So, the population of wild birds does not work as an indicator reflecting environmental performance for each management practice in this CPFM program. The number of wild bird species can also be a 'state' indicator. But, in case of the number of wild bird species, this has a limitation in utilizing it as a 'state' indicator for evaluating an environmental performance because a change in the number of wild bird species can be recognized only over a long-term period. It is also not easy to get data on this indicator if we do not have an observation network as much as the

population of wild birds. As we examined in the above, both indicators could not reflect differences in wildlife biodiversity depending on management practices of agricultural land. So, in order to seek an indicator capable of reflecting differences in an environmental performance of lands as habitats depending on land management practices, we observed the amount of bird feces in paddy fields under different management practices. By analysis of data on the amount of bird feces, it was found that it could be used as an effective 'state' indicator that can express changes with management practices in the light of the fact that the amount of available feed supplied from paddy rice fields determined the survival rate of wildlife species. As the amount of bird feces can be easily measured on land area-base, so we can get data needed for the evaluation of the environmental performance of a policy measure or farming or management practices in agricultural land.

In order to integrate indicators or policy inventory into policy evaluation, it is necessary to link descriptive indicators such as 'driving force' and 'state' indicators to 'performance' indicator and 'response' indicators. As 'response' indicators, we can mention some indicators as shown in Table 4. In a process implementing a policy measures or program, farmers' response to the policy is the most important at the first step. In case of incentive policy, farmers make decision of whether they adopt optional activities or not in response to a lot of factors including the size of financial support (compare to benefits and cost) and their capability etc. In turn, the government determines the whole budgets and the location and the scale of target area on the basis of farmers' responses and physical conditions of land. The success or failure of a given

Table 4. Description of indicators defined in the analysis of the CPFM program

Type of indicators	Indicators
Driving force	• Land area under specific farming or management practices
State	• Population density • Number of species • Amount of feces
Response	• Monetary support • Farmers participating • Public perception

agri-environmental policy is determined by the actual implementation. So, it is needed to check whether farmers practice it or not actually. As long as budget is supported by tax as in incentive program such as CPFM, the perception on the program by the public as well as the performance of policy measures will play an important role in determining whether the government should sustain it or not. These factors will be taken into consideration in improving a policy measure or program by feedback process altogether with 'performance' indicators for ex post evaluation. Here, we suggested 3 indicators as 'response' indicators: monetary support, farmers participating, and public perception. Of them, the size of monetary budgets is thought to be comprehensive indicator because it is the results of the other indicators, namely reflecting farmers' behavior, government' willingness, the public' reactions to environmental outputs etc. As we mentioned in the above, the annual increase of subsidiary budgets for the CPFM program was linked to the increased population and species of migratory birds. Although the response of the public and the numbers of farmers were not surveyed, we could guess indirectly the response from the fact that there was a rise of the total land area subjected to CPFM program.

Government can modify the orientation and intensity via a selection or design of a new policy from environmental outputs of a policy program. For a government to design a new policy or to modify the policy in work, information on a variety of policy instruments are needed. In this aspect, policy inventory should be able to give policy maker information such as linkages between policy measures and environmental factors and their potential impacts on environmental factors or indicators(state indicators) especially, in the field of water quality, water use, biodiversity, soil erosion (soil quality), nutrient balance and pesticide use. Korean government could extend the CPFM program with time on the basis of a linkage between the population of the wildlife ('state' indicator) and the size of CPFM land area ('driving force' indicator) or the size of monetary budgets ('response' indicator). As we see in this case study, it is needed to establish adequate indicators (such as those in shown in Table

4) depending on the characteristic of each environmental element and environmental performance of a policy should be interpreted and evaluated within the DSR framework to make it successful.

Conclusions

The CPFM program, one of environmental policies, is related to agriculture, exactly management of paddy lands during winter fallow period. As a good example of integrating biodiversity into a policy, this program has been extending annually.

As the CPFM program is directly related to agricultural activity, we tried to apply this case in evaluating a policy by both the existing OECD indicators and some indicators suggested in this approach.

For a systematic evaluation of environmental outputs of policy, first we need to identify 'driving force' indicators, and then to link them to 'state' indicators. In this approach, the driving force was identified to be management practices selected as an option depending on the contract under CPFM program and the area of paddy lands in each case. four types of farming or management practices offered in this CPFM program was based on linkages between management practices ('driving force' indicator) and the population of wild birds ('state' indicators) and on some scientific results of other researches. Studies on this linkage are very important in view of determining the content of the policy and providing the rationale as well. Despite these linkages, each management practice had a limitation in matching directly to the population of wild birds due to their migratory behavior. So, we adopted the amount of bird feces as a complementary indicator. This indicator could be directly linked to management practices of paddy field.

The 'state' indicator is to be linked to 'response' indicators in order to ensure that a policy be successfully implemented. Here, we established the size of total monetary support, the number of farmers participating (indicating farmers' behavior) in the CPFM program, and public perception as 'response' indicators. These indicators are of significance in that they play an important role in modifying the policy or determining

policy priority. Even though a quantitative study on the linkage between 'state' indicator and 'response' indicators has not been done yet, we think that it will contribute in orientating agri-environmental policy or adjusting subsidiary payments to encourage farmers to adopt a good farming practice. The size of total monetary support in this CPFM might be a comprehensive 'response' indicator reflecting the social and economic situation. The results from 'response' indicators can be fed back to 'driving force' indicators via policy making processes. For policy maker to do feedback to the next step with responses, a lot of information on policies is needed. Therefore, for policy maker to help easily understand policies, each policy needs to be classified into some environmental category by preliminary analysis of linkages between policies and environmental factors. If the degree of linkages between them can be scored or graded, it would be very helpful in policy making. From this point of view, policy inventory works of OECD need to be done toward this direction.

Conclusively, we expect this approach will be a good example of policy evaluation within DSR framework. In order for policy makers to use indicators easily, more works on development of indicators especially in the field of biodiversity are needed.

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