

# **SOCIAL AND ECONOMIC EVALUATION OF THE MULTI-FUNCTIONAL ROLES OF PADDY FARMING**

Suh Dong-Kyun  
Rural Development Administration, RDA  
250, Seodun-dong, Kwonson-gu,  
Suwon-si, Keyonggi-do,  
441-707 Korea

## **ABSTRACT**

*This Bulletin discusses the multifunctions of agriculture in Korea. These include food security, conservation of the environment (especially management of water resources), recreation, and preservation of the social and cultural amenities. The Contingent Valuation Method was used to give a monetary value to nine of these functions. The results showed that their value was between US\$9,751 million and US\$11,458 million. Even at the lower end of the range, this is more than the value of the harvested rice (US\$8,368). However, the value of these multifunctions is not represented in the market price. To compensate for this market failure, appropriate government policies are needed.*

## **INTRODUCTON**

The launching of the World Trade Organization (WTO) has had a significant effect on world agricultural production and trade. The WTO system pursues trade liberalization for all agricultural products. It also aims at eliminating or reducing various domestic production supports which distort world trade. Implementing these agreements inevitably means a change in the structure of world agricultural production. More specifically, it will raise the production share of current exporting countries in the world's agricultural market, while reducing that of current importing countries.

If the role of agricultural production in each country is confined to providing commodities that are traded on the world market, then the principle of comparative advantage implies that implementing these agreements will enhance the well-being of each country. However, food-importing countries assert that agricultural production provides more than marketed commodities, and the effects of liberalizing world agricultural trade could be very complicated.

In March 1998, the OECD meeting of

the Committee for Agriculture identified the benefits of agricultural production to the environment and rural development. These were termed the "multifunctionality" of agriculture. Since then, the OECD Committee has been carrying out an analytical study of the multifunctionality of agriculture. This paper summarizes some of the results.

Not only does agricultural production provide food, it also maintains rural amenities and preserves the natural environment by contributing to water resource management, soil conservation and biodiversity. Furthermore, agricultural production contributes to rural viability, and helps preserve traditional culture, food security and food safety. If these extra functions are closely linked with agricultural production, then a reduction in agricultural production in any country may result in environmental degradation, a food crisis, and damage to the rural economy and the cultural heritage.

In general, multifunctional roles are formed by the external economies of agriculture. They have the characteristic of a public good. However, the general public that benefits from these multifunctional roles does not place a proper value on them. If

Keywords: food security, Korea, market failure, multifunction, paddy, recreation, rice

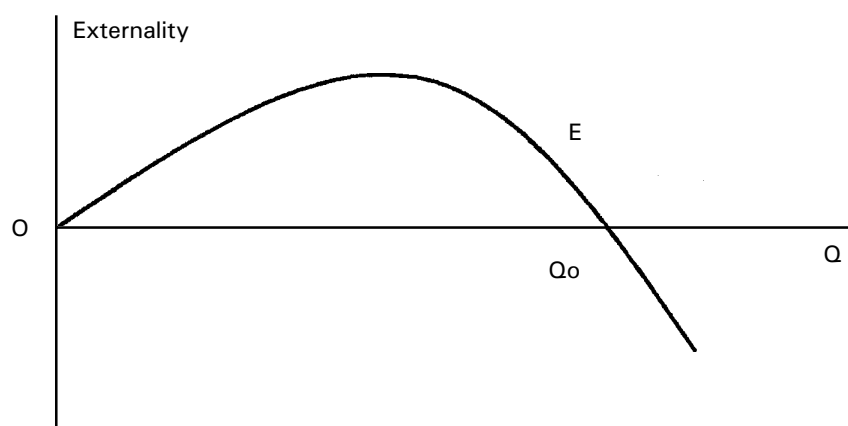


Fig. 1. Relationship between agricultural production and externality

these functions are not traded in the market, policy intervention may be required in order to maintain them.

This Bulletin estimates the economic value of the multifunctional roles of paddy rice farming, and suggests how to implement policies to protect them.

#### AGRICULTURAL PRODUCTION AND ENVIRONMENT

Agricultural production has both a positive and a negative effect on the environment. Thus, the overall effect needs to be assessed. Most studies, including those of OECD (2000a) and Romstad *et al.* (2000), suggest that the effect is mainly positive when the level of production is low. When a large volume is produced intensively, the effect may be mainly negative. This relationship between the level of agricultural production and the positive externalities is shown in Fig. 1. Agricultural production generates positive environmental externalities if commodity output is lower than  $Q_0$ . However, it generates negative externalities if commodity output is higher than  $Q_0$ .

Therefore, liberalizing the world's agricultural market could affect each country's welfare in two opposite ways. It might improve efficiency and increase each country's welfare by completely realizing the principle of comparative advantage. On the other hand, it might cause unexpected damage to some countries by reducing their domestic agricultural production, leading to a loss of multifunctions.

Because agricultural production generates so many and such varied environmental effects, positive and negative, an overall evaluation of the impact of agriculture on the environment needs a unit that can be applied to these effects. Kim (2000) evaluated the overall environmental impact of Korean agriculture by applying the System of Integrated Environmental and Economic Accounting. This was developed by the United Nations to construct a national account, which included the impact of economic activities on the environment and natural resource stocks. The common unit used in this work is their monetary value. Kim (2000) derived these values from information on the replacement costs of environmental output, such as the cost of treating polluted water, or the cost of generating the same environmental benefits in other ways. The impact of agricultural production on water pollution (N, P, BOD), greenhouse gases ( $CO_2$ ,  $CH_4$ ), acid rain ( $SO_2$ ,  $NO_x$ , HC) and the levels of heavy metals (e.g. zinc and cadmium) in soil have been evaluated. The contribution of agriculture to soil conservation and gas absorption have also been evaluated. However, the two major environmental outputs of rice production, flood control and water resource management, have not been evaluated.

Kim (2000) has shown that the value of the positive environmental contribution exceeds that of the negative impact for almost all types of crop production in Korea. The contribution of rice to the GDP increases by 6% when the impact of rice production on

the environment is taken into account. The results of Kim (2000) can be compared to those of Hong and Kim (1998), who applied almost identical methodologies to all agricultural and non-agricultural industries in Korea. They found that the overall GDP of Korea declined by more than 10% when the impact on the environment is accounted for. This evidence suggests that the contribution of agricultural production to environmental preservation is greater than that of other industries, and that the overall impact of agricultural production on the environment is a positive one.

Agricultural production affects environmental quality both positively and negatively. Thus, agricultural chemicals contaminate surface water, groundwater and soil if they are not used in a proper way. The intensive use of pesticides may damage biodiversity by threatening wildlife. Wastes from intensive livestock raising are the main source of water contamination in many countries. Fossil fuels used for agricultural purposes emit CO<sub>2</sub> and other gases that generate the greenhouse effect.

At the same time, however, agricultural production also contributes to environmental conservation. Agriculture contributes to flood control and water resource management. It helps clean air and promotes biodiversity.

It is often asserted that rice farming in an Asian monsoon climate contributes to water resource management, because it conserves water over the rainy summer season and releases it during the dry season. Crops absorb CO<sub>2</sub> gas from the air as they grow, while crop rotation contributes to soil conservation.

Both the positive and negative effects on the environment of Korean paddy rice farming have been studied (Suh 2000). Suh (2000) surveyed 1,742 urban households. They were asked to indicate which indirect benefits were most important to them (Table 1). Food security was seen as more important than other functions. Urban inhabitants placed a positive value on flood control (54.6%), air purification (54.5%) and a pleasant environment (49.2%). At the same time, they recognized the negative functions of agricultural production, particularly the contamination of water (35.3%) and soil (about 33.4%).

#### MULTIFUNCTIONS OF PADDY RICE FARMING, AND THEIR ECONOMIC VALUE

Paddy rice is one of the most important crops in Korea. In 1999, it contributed 30.6% of the total agricultural value of production and occupied about 56% of total

Table 1. Extent of recognition of the multifunctionality of paddy rice farming in Korea (%)

Classification		High	Medium	Low	Zero	Total
<b>Positive effects</b>	Food security	92.2	6.9	0.8	0.1	100.0
	Mitigation of soil erosion	64.0	26.7	7.3	2.0	100.0
	Food control	54.6	33.3	8.7	3.4	100.0
	Air purification	54.5	32.6	9.4	3.5	100.0
	Water purification	48.6	31.9	14.2	5.3	100.0
	Conservation of water resources	43.6	42.1	10.3	4.0	100.0
	Pleasant environment	49.2	34.3	12.9	3.6	100.0
	Beautiful landscape	45.6	38.9	12.5	3.0	100.0
	Transmission of traditional culture	44.0	37.4	15.0	3.6	100.0
<b>Negative effects</b>	Contamination of soil	33.4	32.1	19.8	14.7	100.0
	Contamination of water	35.3	30.3	20.8	13.6	100.0
	Deterioration in food quality	25.1	34.4	20.4	20.1	100.0

Source: Suh 2000

farmland. Three methods are often used to evaluate multifunctional roles: the replacement cost method, the contingent valuation method (CVM) and the travel cost method.

### **CONTRIBUTION OF RICE FARMING TO THE ENVIRONMENT, AND THE ECONOMIC VALUE**

The replacement cost approach assesses the value of a natural resource on the basis of how much it would cost to replace or restore it if it is damaged. The value of the damage is based upon:

- The restoration or replacement cost;
- Other use-values for which no market price is charged, *and*;
- Any fees or other payments which would have been collected by the government.

#### **Flood control**

In Korea's monsoon climate, more than 60% of the year's precipitation falls during the three summer months (June, July and August). This is also the rice-growing season. Hence, many dams are required to manage surface water. However, flood damage occurs every year, as the result of sudden downpours.

Paddy fields help control flooding because they contain water over the wet season and release it over the dry season. They are estimated to store a total of 2,733 million mt of water, valued at US\$1,208 million.

#### **Conserving water resources**

Rice production contributes to water management. Paddy fields are under water during the rice crop, and have the function of storing underground water. Some 55% of the water stored by paddy fields goes to rivers, while the other 45% is stored as underground water, accounting for 5,420 million mt annually. The value of this function is about US\$1,224 million each year.

#### **Climate mitigation**

About 6 mm of the water in paddy fields evaporates every day. This brings down the air temperature during Korea's hot summer. The value of the energy which would

otherwise be needed for cooling amounts to about 346 million kl of crude oil. The value of this function is about US\$1,175 million.

#### **Preventing soil erosion**

Paddy fields also contribute to soil conservation. Annual soil losses in Korea amount to about 1.17 million mt. A significant amount of cultivated soil is protected by the fact that it is used for paddy rice. The value of paddy fields in reducing soil erosion is estimated at US\$713 million.

#### **Air purification**

Rice production helps clean the atmosphere by absorbing 14 million mt of CO<sub>2</sub>, and emitting 10 million tons of O<sub>2</sub> annually. The value of rice crops in purifying air is about US\$1,613 million.

#### **Water purification**

The total amount of contaminated water which is purified in paddy fields each year is estimated at 704 million mt. This value from rice production of purifying polluted water is about US\$1,651 million.

#### **Organic waste disposal**

Rice farming saves about 23 million mt of applied nitrogen by using organic wastes as fertilizer. The value of this function of organic waste disposal crops is about US\$558 million each year.

#### **Preservation of bio-diversity**

An important aspect of preserving bio-diversity is to conserve the native species and varieties of each country. Substituting imported products for domestic ones may destroy native flora. For instance, three major agricultural crops of Korea until the 1940s were cotton, wheat, and soybean. As a result of massive imports of those products, native varieties of these plants have since disappeared from Korea. This means a huge loss of important genetic information over only a few decades.

Lee and Rhim (1999) have suggested a specific example of the way in which rice

production contributes to bio-diversity. Their example is the contribution of paddy fields to the survival of cranes. Cranes are birds which are under the risk of extinction. Fifteen percent of the world's crane population choose Korea as a habitat during winter. In order to preserve cranes, there is a need, not only for a safe winter habitat, but also a winter food source.

Lee and Rhim noticed that the rice grains remaining in paddy fields after the harvest are a good source of food for the cranes. Protection of cranes is only one example of the contribution of agricultural production to bio-diversity.

In addition, paddy fields have the functions of preventing acidification etc. On the other hand, paddy fields also generate environmental pollution. Chemical fertilizers used in paddy fields may pollute water and soil, while growing rice emits about 400 thousand mt of methane gas annually in Korea alone.

### **SOCIAL AND CULTURAL BENEFITS OF PADDY RICE FARMING**

In Asia, the sight of agricultural land growing healthy crops is a symbol of affluence, and is felt to be a very beautiful kind of landscape. In addition, rural areas provide people with various educational experiences, and preserve the nation's cultural heritage. This function is less controversial than some of the others. Most countries agree that rural areas provide amenities and cultural values. However, the importance placed on rural amenities and the value of the cultural heritage may differ from one country to another.

They are likely to be higher in a densely populated country where cities are close to rural areas, than they are in a lightly populated country where rural areas are geographically remote from urban ones. The cultural heritage may have a greater value in developing countries with rapid urbanization, where there is concern about preserving traditional culture.

There is no objective monetary value for rural amenities and the value of the cultural heritage from agricultural production. However, people in Korea want to see paddy fields being cultivated, not lying fallow.

People also want to see rural communities where the traditional culture is preserved.

### **The value of the agricultural landscape**

Korea's agricultural structure and practices are based largely on rice. Rice production has a special beauty to the Korean people. It generates a feeling of life and movement in the spring, when rice is being transplanted. It provides spacious green fields in summer. In the autumn, it creates a feeling of abundance at harvest time.

The Contingent Value Method (CVM) is a way of assessing the subjective value of a commodity. Responses are sought from individuals to find what they would do in a particular hypothetical situation. This method has been widely used in recent years. Questionnaires were sent to the general public who benefit from the environment, to ask them how much they would be willing to pay (WTP) for an improvement in the environment. Thus, they are asked to state the maximum amount of compensation required to maintain their original utility level, if rural scenery is harmed.

CVM type studies are a very useful way of obtaining both practical and aesthetic values. However, the approach has been criticized because the questions it asks are hypothetical, and the results vary from one study to another. Sometimes the results may be biased, so that the values obtained are too high or too low. For example, there may be strategic bias. If respondents believe that their response will affect a policy that they favor, then they may intentionally over- or under-report their WTP.

A survey by the author using CVM found that urban people in Korea are willing to pay about US\$66.4 per household to safeguard rice production and rural areas (Suh 2000).

### **The value of the recreation function**

Paddy fields and uplands provide, not only a beautiful rural landscape, but also a unique natural, cultural, and social environment. Urban people can visit rural areas to find leisure and relaxation.

One active way of using rural amenities is to visit farms used for homestays. At the

Table 2. Value of urban residents traveling to rural areas for recreation and relaxation

Unit: US\$

Travel cost (\$)	No. of visits	Total cost (\$ million)	Economic evaluation (\$ million)	Remarks
88.6	3.9	4,036	2,572	Total cost * paddy area/agricultural area
			586	Total cost * paddy area/(agricultural area + forestry area)

Paddy area = 1,149 thousand ha. Agricultural area = 1,889 thousand ha (1999)  
Forestry area = 6,427 thousand ha (1999)

end of 1999, there were 379 farms used as homestays in various parts of Korea. However, homestays are a very small part of rural amenities. Most people in cities travel to rural areas to visit their relatives or for some other purpose. The travel cost method uses the cost of traveling to a recreation site as a means of inferring the recreational benefits which that site provides. Questionnaire surveys are used to collect data on the number of visits that an individual or household make to a site, in relation to the travel cost.

Suh (2000) showed that Korean people visited rural areas on average 3.9 times each year for various purposes (Table 2). The most common purpose was to visit relatives. This came to a total cost of about US\$586-2,572 million, which could be seen as the value placed on recreation and relaxation in the countryside.

### FOOD SECURITY

FAO defines food security as access by all people at all times to the food needed for a healthy and active life. According to FAO, achieving food security means ensuring that sufficient food is available, that supplies are relatively stable, and that those in need of food can obtain it. OECD (1998) suggested that food security has three dimensions: availability, access and utilization. However, there is a tendency to measure the degree of food security only in terms of the availability dimension. OECD (2000b) suggests that there are two ways of achieving food security: self-sufficiency and self-reliance.

Indicators of food security can also vary, according to the strategy chosen to achieve it. When self-sufficiency is

emphasized, the self-sufficiency rate (i.e. the ratio of domestic food to total consumption of food) is the main indicator of food security. If self-reliance is emphasized, various other indicators of food security are used. World cereal stocks may be compared to cereal consumption, or the ratio of supplies to requirements for five main exporting nations, or the level of cereal production in low-income countries with a food deficit (FAO 1999).

There is no empirical evidence showing whether domestic food production in Korea contributes to food security or not. Korea has achieved almost complete self-sufficiency in rice. However, the overall self-sufficiency rate for all foods is less than 30%, and Korea recorded an agricultural trade deficit of US\$5.4 thousand million in 1999. Thus, the current agricultural trade deficit is already quite large.

Food security provides positive externalities such as social stability and national security for every country. In fact, the Asian financial crisis of 1998 reminded Koreans that food security is one of the most important effects of domestic food production. Had rice stocks not been high enough when the financial crisis struck, Korea would probably have faced severe social unrest. On the other hand, like a national defence system, food security has the characteristic that it is a public good, from which no-one can be excluded. Korea can be sure of its food security in the long term only if the existing resource base for rice production is maintained on a sustainable basis.

This is particularly the case with rice, since the trade volume is small compared with the total world output, and the export supplies are unstable. Over 90% of the

world's rice is produced in Asia, while only 5% of global production is internationally traded. In this sense, the global rice market is a thin market, in which a small increase demand can cause the price to rise rapidly.

In 1980, cold weather damaged the Korean rice crop. As a result, Korea was forced to import a large amount of rice, at a price more than three times higher than the world market price. As a result, there is an emphasis today on maintaining domestic production for food security in Korea.

### OTHER FUNCTIONS

In addition, paddy rice farming contributes indirectly to the protection of forests and wildlife habitats. Rice straw and rice husk, the byproducts of the rice harvest, serve as a source of organic fertilizer and as a feedstuff for livestock, especially cattle. This not only helps prevent woods and forests from being overexploited, but also contributes to the protection of wildlife habitats.

Rice farming also maintains the economic viability of rural communities, through the revenue from rice. As a result, rural people are more likely to remain on their farms, thereby avoiding excessive concentrations of the population in urban areas. As described in the previous section,

it also provides a scenic rural landscape and a context for traditional Korean culture.

### TOTAL VALUE OF MULTIFUNCTIONAL ROLES OF AGRICULTURE

The economic valuation of environment conservation was estimated in the previous section, using the replacement cost method. The landscape was evaluated by the contingent valuation method (CVM), and recreation and relaxation by the travel cost method. This study evaluated nine multifunctional roles of agriculture and rural areas: preventing floods, conserving water resources, preventing soil erosion, preventing landslides, organic waste disposal, air purification, climate mitigation, provision of landscape and recreation and relaxation.

The value of the multifunctional roles of paddy rice farming thus obtained were \$9,751-11,458 million in Korea as a whole (Table 3). However, the monetary value of traditional culture, the protection of biodiversity, the conservation of populations of wild animals and plants, *etc.* were not considered. In future, it is important to evaluate these functions as well, using appropriate methods of assessment. How to maintain the multifunctional roles of agriculture is a very important policy issue.

Table 3. Economic evaluation of multifunctions in paddy rice farming

Methods	Function	Quantities involved (million mt)	Value (million US\$)
Replacement cost approach	Preventing floods	2,733	1,208
	Conserving water resources	5,420	1,224
	Purifying water	704	1,651
	Preventing soil erosion	1	713
	Disposal of organic wastes	N:23	558
	Air purification Climate mitigation	CO <sup>2</sup> :14, O <sup>2</sup> :10 5,171	1,613 1,175
Contingent Valuation Method	Landscape (minimum value)		1,023 (745)
Travel Cost Method	Recreation and relaxation (maximum value)		586 (2,572)
Total			9,751 (11,458)

1US\$ = 1,264.5 Korean won (in Y2000).

## POLICY ISSUES

The value of rice production in Korea goes beyond the provision of a staple food. Paddy rice farming also makes a significant contribution to environmental conservation, as well as giving social and cultural benefits and food security. The estimated value of only nine multifunctions is in the range US\$9,751 - 11,458 million. This is higher than the total value of the harvested rice, which is US\$8,368 million.

It cannot be claimed that rice paddy farming is always friendly to the environment. On the contrary, the agricultural chemicals used can adversely affect the environment. However, these negative effects can be reduced by following Low Input Sustainable Agriculture (LISA). Examples are organic farming, integrated pest management and integrated nutrition management systems. An increasing number of rice farmers in Korea are in fact now adopting such methods.

The market system cannot fully reflect the positive external effects generated by rice paddy farming, in terms of the market prices paid for rice. This means a kind of market failure. To correct this market failure and ensure efficient resource allocation, the government can pay for the perceived benefits by means of appropriate policies. Since the positive functions of paddy rice farming are closely linked to production activities, policy measures should be directed toward maintaining the existing resource base for producing rice.

To some extent, the loss of multifunctionality is irreversible. Once agricultural resources, particularly arable land, are damaged or disrupted, their rehabilitation takes a long time. It may not be possible to reactivate the multiple functions. This is especially true of irrigated rice. Paddy rice farming, with its careful control of water, needs level fields and a complex system of ditches and dikes. These soon deteriorate if they are not used, and it may be expensive and difficult to restore them.

Some indirect benefits, such as flood control and water resource management, are not directly linked with rice production itself. Those outputs can be maintained if paddy fields are preserved, regardless of whether rice is being grown. However, it is

extremely difficult to preserve uncultivated agricultural land in over-populated Korea, because there is a strong demand for land for industrial and residential uses.

Other environmental outputs, such as soil conservation, water purification and contributions to biodiversity, are directly linked with agricultural production. Suh (2000) has investigated the demand for rural landscapes and recreation in rural areas among Korean people. His study shows a very high level of willingness to pay for rural amenities, and proves that Korean people are willing to pay more for domestic agricultural products than the market price.

It seems that Korean people are willing to pay a substantial amount of money to subsidize rural communities and preserve agricultural land. This shows that the current prices of agricultural outputs and land do not represent their social value, and that a certain amount of market failure is involved in resource allocation.

There are no empirical studies to show whether food security is positively linked with domestic food production. The experience of Korea suggests that it is. Food security implies preserving a minimum food production level in a situation of food crisis.

It is important to note that free trade agreements force importing countries to eliminate import restrictions, but cannot force exporting countries to export their food stocks, even in a food crisis.

If there is a market failure associated with noncommodity outputs, then liberalizing trade and eliminating production supports may not be the best policies. The optimal policy mix must achieve gains from trade, and at the same time eliminate failures in the domestic market. In such a case, domestic subsidies may be required to internalize the externality. Alternatively, some level of trade restrictions may have to be imposed to ensure a sufficient level of domestic production.

The inseparable link between commodity and noncommodity outputs must be evaluated in a comprehensive way. Production of a single noncommodity output may be joined with the production of a commodity. At the same time, each noncommodity may be jointly produced with other outputs of the same kind. It is important that the value of multifunctions should be estimated according

to a precise, scientific methodology. If we estimate each function separately and add them all together, there is likely to be too high a total value. Instead, we should derive the scientific, integrated value, while accurately assessing the value of each function.

## REFERENCES

- Kim, E.S. 2000. Green GDP in Korean Agricultural Sector. *Proceedings of the Korean Environmental Economic Association Meeting in 2000*, pp. 153-179.
- Eom, K.C., S.H. Yun, S.U. Hwang, S.K. Yun, D.S. Kim. 1993. Public Benefits from Paddy Soil. *Journal of Korean Society of Soil Science and Fertiliser* 26, 4: 314-333.
- FAO. 1999. *Assessment of the Impacts of the Uruguay Round on Agricultural Markets and Food Security*. CCP 99/12 Rev. Rome.
- Hong, J.H. and S.W. Kim. 1998. Compilation of Green GDP using the system of integrated environmental and economic accounting: the Case of Korea. *Proceedings of the Korean Environmental Economic Association Meeting in 1998*, pp. 275-298.
- Kwon, O.S. 2001. Empirical Work on Multifunctionality: The Case of Korea. Report to OECD Directorate for Food, Agriculture and Fisheries. (Unpub. Mimeograph).
- Lee, W.S. and S. J. Rhim. 1999. Current Status and Management of Cranes in Korea. *Proceedings of IUCN/WCPA-3 Seoul Conference*, pp. 185-195.
- OECD. 2001. *Multifunctionality: Towards an Analytical Framework*. Paris, France.
- OECD. 2000b. *The Impact of Further Trade Liberalisation on the Food Security Situation in Developing Countries*. Paris, France.
- Romstad *et al.* 2000. *Multifunctional Agriculture: Implications for Policy Design*. Agricultural University of Norway.
- Suh, D.K. 2000. Social and Economic Evaluation of the Multifunctional Roles of Paddy Farming. (Unpub. Mimeo-graph).