An Economic Analysis of Preservation versus Development of Coastal Wetlands around the Youngsan River

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Abstract : This paper addressed the specific benefits and costs for converting coastal wetlands around the Youngsan River in Korea into agricultural use. In conventional BCA excluding passive-use values, two scenarios were employed: in Scenario 1 it is assumed that the effects of agricultural production and its air quality improvements occur after 10 years from the beginning of the project. With this optimistic estimate this period is 5 years shorter than the status quo due to the expected technical advances for removing the salt from reclaimed land. Scenario 2 is assumed that the period is normally 15 years without considering the technical changes. The results showed wetland development is preferred to its preservation in Scenario 1, yielding NPV of $49,030 thousand at the discount rate of 8 %, and IRR of 8.28 %, B/C ratio of 1.03. In contrast to Scenario 1, Scenario 2 rejects economic feasibility for the development project at the discount rate of 8%, yielding a negative NPV of $271,575 thousand, IRR of 6.5 % and B/C ratio of 0.84. In sensitivity analysis, a

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change of agricultural production factor is most sensitive to a change of IRR under Scenario 1, while under Scenario 2 lost fishing rights cost factor is most sensitive. With an argument of extended BCA including passive-use values, the estimates of IRR are 7.42 %, 5.42 %, and 4.06 % for 1 year- payment, 5 year-payment, and 10 year-payment of passive-use values, respectively under Scenario 1. Under Scenario 2 the estimates of IRR are 5.85 %, 4.25 %, and 3.09 %, respectively. They show that consideration of passive-use in BCA can play a crucial role in reversing the results suffered by weak persuasion for wetland preservation. Further analysis using a goal-seeking model produced the specific minimum magnitudes of passive-use values so as to preserve wetlands in this project according to national level and household level with some different possible discount rates (5%, 6%, and 7%). If about fifty-eight percent of all households in Korea can have their annual WTP of $5 to $16 for preserving wetlands only for 10 years, wetlands would progressively be protected even under the worst scenarios of low discount rates. Finally, this paper provided a direct and intuitive comparison of total wetland preservation value and total development values for agricultural use. The results illustrated that total value of wetland preservation is about three times much higher than that of development for agricultural use, even though this method is quite sensitive to criteria and methods of resource allocation. It is noteworthy that only agricultural use will be less efficient than wetland preservation if the project does not include industrial use of reclaimed lands.

I. Introduction

The debate concerning the preservation versus development of coastal wetlands is one in which no easy compromise is reached but which nevertheless needs to be resolved. This paper attempts to employ benefit-cost analysis as a total assessment approach with monetary terms, focusing on social economic efficiency and distributional equity for public policy.

This paper discusses how different incentives to preserve and convert wetlands transfer into socially optimal levels with inter-temporal transfer and irreversible considerations. Before undertaking benefit-cost analysis, various theoretical issues are discussed, including efficiency and equity, shadow price, discount rates, risk and uncertainty, the different view of economic and financial analysis, and conventional versus extended BCA. In order to analyse the economic feasibility of wetland development, the specific factors and magnitudes of benefit and costs are identified with and without the proposed project. After this identification, the results from various perspectives using BCA are derived including net present value, internal rate of return, and sensitivity analysis in conventional and extended BCA, and in particular goal-seeking analysis for the minimum level of passive-use values to preserve the wetlands in the project. Finally an intuitive comparison of total wetland preservation value and wetland development value for agricultural use is illustrated.

As an empirical case in the paper, the coastal wetlands around the Youngsan River holds four key coastal wetland sites of the forty-two South Korean ones, which meet Ramsar waterfowl-based criteria, and a fisheries resource reserve. It consists of estuaries, sand and mud-based coastal wetlands, salt marshes, salt-pans, and so on with an area of 542.7 km2, which covers 22% of South Korean coastal wetlands. They contain valuable plants and animals and produce a wide range of fishes such as oyster, shellfish, small octopus, mullet, sea bass, goby, lug-worm, and so on, which are about 25% of the total fish harvest in South Korea. In addition, they play a significant role in flood control, erosion control, pollution assimilation, recreational activities, and other ecological functions. In spite of ecosystem services that these wetlands provide, the Korean government in 1998 undertook an economic feasibility study of coastal wetland development in the areas (See Korea Industrial Research Institute (1998) for detailed information). The development project, however, was delayed as a consequence of the economic crisis in the late 1997 and the strong protest of NGOs, even though the project was estimated to yield an internal rate of return of 10.97%, a benefit/ cost ratio of 1.139 and a net present value of 146,715 million won in a conventional BCA.

II. Wetland economics: preservation and development

Public policy on wetlands attempts to balance the public's interest in conserving wetlands in respect of the benefits they provide with the opposite interests in converting wetlands into other economic uses. While wetland economics pursues the balance between the marginal benefits of protecting and converting wetlands, more appropriate evaluations of those benefits are often limited.

1. Socially optimal preservation and development

How do different incentives to preserve and convert wetlands translate into observed and optimal levels of wetland preservation and conservation? Figure 1 illustrates a stylised framework with the factors involved (Larson, 1994). The horizontal axis represents the total initial stock of wetlands. The initial stock has subsequently been allocated to one of two categories: remaining/protected wetland size P (measured from the left-hand side) and converted wetland acreage C (measured from the right-hand side). The vertical axis represents a value such as dollars per ha.

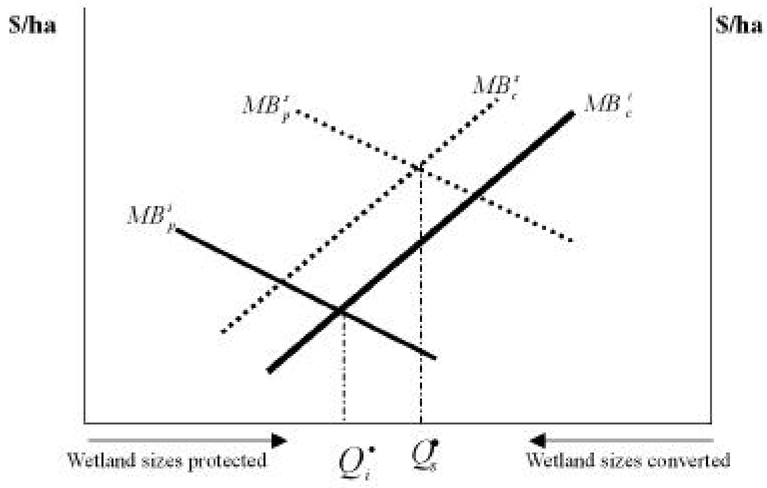
In Figure 1 the net marginal benefits of wetland protection, MB_p^i, is obtained by protecting an incremental acre of wetlands.[1] This curve is assumed to be relatively low since social benefits, such as flood control, water quality improvement, fish and wildlife habitat, and recreational opportunities, are not reflected. MB_p^i increases as the remaining area of protected wetlands decreases (moving from right to left). In the meantime, the net marginal benefit of wetland conversion, MB_c^i, is realised by converting an incremental acre of wetlands.[2] In contrast to the benefits from wetland protection, MB_c^i may be relatively high, since conversion makes more tangible or intensive uses that provide returns directly. This benefit declines as the acreage of converted wetland increases (moving from right to

1) This is net benefit deducted direct cost for wetland protection, such as monitoring and enforcement costs, but not for economic returns foregone, the indirect opportunity costs of not converting. Foregone economic returns are embodied in the marginal benefits to conversion.

2) As with MB_p^i, this net benefit MB_c^i is adjusted for direct conversion costs, such as drainage costs, but not for indirect opportunity cost, such as the wetland benefits foregone. Foregone wetland benefits are embodied in the marginal benefits of protecting wetlands.

left).

<Figure 1> Optimal wetland conversion/protection



Source: Adapted from Larson (1994)

In conventional economic analysis, not considering intangible benefits and costs, the optimal allocation of the stock of wetlands is represented by the point (Q_i^*) where the two marginal benefit curves (MB_p^i and MB_c^i) cross. At this point, protecting an additional hectare would cost more in terms of foregone benefits from conversion than would be gained in benefits from protection. Likewise, converting an additional hectare would cost more in terms of foregone benefits from protection than would be gained in benefits from conversion.

This simple framework can be extended to capture two important dimensions in wetland economics. First, the difference between the indirect benefits or incentives to protect and convert wetlands can be illustrated. Second, the changes in wetland policy and in conversion trends can be depicted. Adding these indirect or intangible benefits by development or protection of wetlands to MB_c^i or MB_c^p, these curves can shift to MB_c^s and MB_p^s, respectively. In the case of an environment-friendly society, such as developed countries' societies where their development and settlement have been accomplished, their indirect benefits to development or conversion of wetlands can be now small relative to their indirect benefits by wetland protection. In other words, the shift of MB_p is much larger than that of MB_c as in Figure 8.1, and *vice versa*. To this end, the socially optimal allocation of the initial stock of wetlands ($Q_s^\bullet$) thus occurs to the right of ($Q_i^\bullet$), representing relatively more wetlands protected and less converted than under the conventional optimal allocation($Q_i^\bullet$).

Even in the absence of complete and accurate data about social benefits provided by wetlands, however, it is possible to estimate the level of social benefits required to justify optimal allocation in specific wetland contexts. Stavins (1990) develops theoretical models of privately optimal and socially optimal use of forested wetlands, and then links them in an econometric analysis of land-use data from 36 counties in the lower Mississippi alluvial plain during the period 1935-1984. He then incorporates alternative estimates of environmental externality values (as indicators of social benefits) in a series of dynamic simulations to estimate changes in forested wetland acreage that would have occurred if private landowners had taken environmental consequences into account in their land-use decisions. He estimates a certain amount of annual environmental benefits that would have justified zero net depletion of forested wetland optimal. He concludes that policymakers should consider ways of narrowing the gap between the actual and the socially optimal allocation of land between remaining and converted wetlands, including tax provisions, easements, and cross-compliance requirements.

Benefits from wetlands are a part of the equation, and costs for wetland drainage and wetland restoration enter into wetland economics as well by defining what conversion is physically possible. Drainage technology and costs influence how far to the left (in terms of Figure 1) remaining wetlands can be converted. By contrast, restoration costs and improvements in restoration technology play a part here in determining how far to the right of Figure 1 the remaining stock of wetlands can be protected (Heimlich *et al.*, 1998).

2. Intertemporality and irreversibility[3)]

A planner is assumed to maximise the present value of net social returns from use of the wetland, the project site. Considering the decision rule of choice between development and preservation of a wetland area with time preference of value, the rule of development would be indicated if:

$$[PV(B_D) - PV(C_D)] > [PV(B_P) - PV(C_P)] \qquad (1)$$

where $PV(B_D)$ = the present value of development benefits

$PV(C_D)$ = the present value of development costs

$PV(B_P)$ = the present value of preservation benefits

$PV(C_P)$ = the present value of preservation costs (e.g. policing. maintenance and monitoring costs)

Now some related assumptions and notation are introduced for intertemporality and irreversibility. The size of project, or scale of development, at any time t is represented by $S(t)$ which is measured in physical units. The foregone benefits from preservation are given

3) It is adapted from Krutilla and Fisher (1975), and Pearce and Turner (1990).

explicitly as a function of scale and time; in symbols, as $B_P[S(t), t]$. That is, the relationship between B_P and S is then negative. B_P decreases with increase in S, and at an increasing rate. And B_P is assumed to be deducted from preservation costs (C_P). In addition to the flow of operating costs associated with a project, already netted out of the B_D term as well, there will be at any time a flow of capital, or investment costs which is positively related to the level of investment: $C=C[I(t)]$ where C is cost and $I(t)$ is investment at time t. Now the planning problem can be stated with an appropriately chosen discount rate, r as:

$$NPV(D) = \int_0^{\infty} E^{-rt}[B_D(S(t), t) + B_P(S(t), t) - C(I(T))]dt \quad (2)$$

Considering g which is the growth rate of the price of preservation benefits relative to the general price level, and k which reflects the discount of development benefits as the rate of technological decay of the project, equation (2) can be rewritten:

$$NPV(D) = \int_0^{\infty} [B_D(S(t), t)e^{-(r+k)t} + B_P(S(t), t)e^{(r-g)t} - C(I(T))e^{-rt}]dt$$

$$= \frac{B_D}{r+k} - \frac{B_P}{r-g} - \frac{C}{r} \quad (3)$$

where every factor is assumed to be constant every year. This equation indicates that the present value of development can be very sensitive to the preservation relative price effect and the technological decay factor. That is, reflecting the rate of growth and the rate of technological decay, development benefits must be higher than preservation benefits for the development to be feasible.

Ⅲ. Theoretical issues on benefit-cost analysis

One of economic tools for comparing the desirable and undesirable impacts of proposed policies is benefit-cost analysis. Benefit-cost analysis (BCA) systematically identifies and organises economic cash inflows and outflow that are expected to result from a proposed public policy or program. Much confusion however surrounds this analysis in practice versus in principle. There is no doubt that BCA has been misused and abused. Therefore, only its appropriate usage can revive its merits.

1. Efficiency and equity

The public project for improving the market failures follows the Pareto improvement principle which is to make at least one person in society better off and no one worst off. In reality, however, any policy decision will not benefit some individuals without harming others. Kaldor and Hicks proposed the 'potential compensation criterion' or 'potential Pareto improvement' which states so long as the gains from a project were sufficiently great to enable the winners to compensate the losers and still result in a net gain then society's welfare would be increased[4], eventually reaching the social economic efficiency.

A problem such as price changes redistributes income: for every consumer who pays more, a producer receives more, and if less, less. Therefore, the compensation principle ignores such changes. Unless

4) In reality, as it is not necessary for compensation to be paid, it is called as a 'potential' Pareto improvement. If compensation were paid the outcome would be a Pareto improvement.

pre-project income distribution is compared with post-project income distribution it will be impossible for public sectors to determine whether a project is in the public interest or not. Integrating distributional judgements into benefit-cost analysis is a way out of the dilemma. There is a long and on going debate in economic theory whether it is correct to incorporate distributional issues into project selection. The introduction of distributive weights into BCA means that that the public sector no longer accepts that costs and benefits are of equal value to all groups in society. It rejects the potential Pareto hypothesis that income is distributed in a socially optimal way. Real world evidence supports this. Tax systems are generally progressive, transfer payments favour the lower income group in society and government aid is usually targeted at depressed regions rather than wealthy regions.

2. Shadow prices and markets

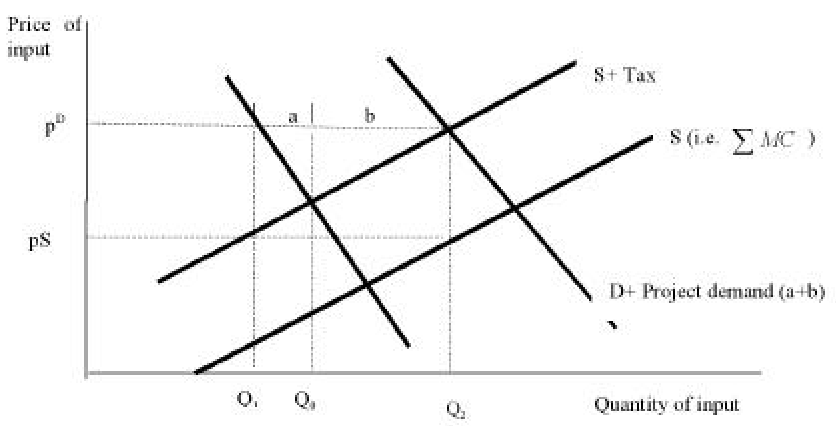
A full BCA will involve the identification of all costs and benefits in monetary terms, where the prices that enter the BCA must reflect their economic value, that is, price ≡ marginal social cost ≡ marginal social valuation. Because of the existence of market imperfections, market prices are often inappropriate. Thus shadow prices have to be estimated and these enter as the correct values into BCA, for both tangibles and intangibles. In some cases the relevant costs and benefits for the purposes of BCA will have no observable market value such as those of non-market goods and services.

Developed countries and shadow pricing

There are some examples of market failures: monopoly, indirect taxes, unemployment, property rights, and foreign exchange. In the case of monopoly, market price will not equal marginal cost in most cases. The appropriate shadow price in the case of monopoly depends on how the rest of the economy will adjust when the project is undertaken. Meanwhile, assume that an intermediate input is subject to indirect tax. In the case of producer's supply price producing by the full amount of the project's demand, and the demand price expecting no growth in output, a+b units of the input is project demand where ‘a’ is a decrease in consumption by non-project users, and ‘b’ is a quantity increase supplied by the firm, in Figure 2. The relevant economic price of the input is marginal values (gross of tax) foregone by non-project uses plus the increase in marginal costs (net of tax) of the firm of the quantity change in supply:

$$\text{Shadow price} = \frac{a}{a= b} P^D + \frac{b}{a+ b} P^S \tag{4}$$

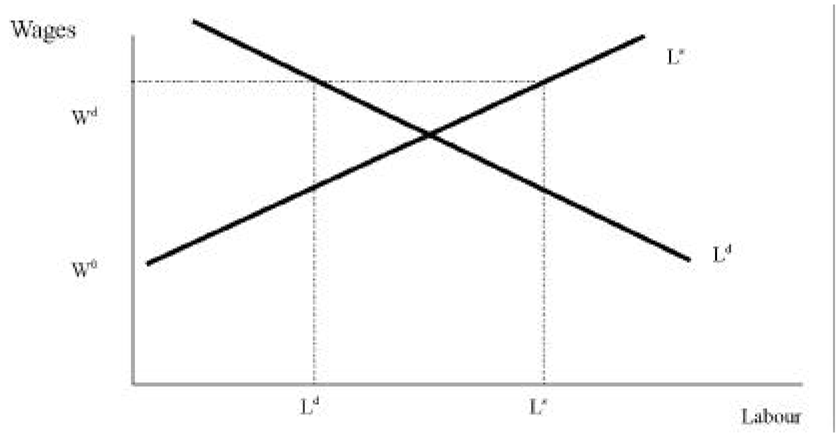
<Figure 2> Indirect taxation, inputs and the derivation of economic values



where $\frac{a}{a+ b}$ and $\frac{b}{a+ b}$ are correctly expressed by the price elasticities of demand and supply respectively.

To determine the appropriate value of unemployed labour in social projects it is necessary to distinguish between two scenarios. Firstly, where a project creates additional employment and secondly, where unemployment is maintained by default of government policy. If there are no macroeconomic costs of employing them, the cost is not their wage but the value of their lost leisure. In Figure 3 unemployment is an excess of labour supply over labour demand, that is, $L^s - L^d$. The labour market fails to clear at wage W^d, perhaps the result of union activity in the market. The correct economic value is approximately between W^d and W^0, which is less than their wage.

<Figure 3> Institutional distortion and unemployment



Developing countries and shadow pricing

Developing countries are characterised by persistent distortions in which market prices systematically fail to reflect marginal social costs and benefits to society of their use: inflation, currency overvaluation, imperfect factor input markets, deficiencies in savings (inter-generational issues), inequality in income distribution, an so on.

<Table 1> The differences between the methodologies of UNIDO and OECD

Numeraire	OECD	UNIDO
	Foreign exchange	Domestic consumption
Unadjusted net benefit stream	NB=(OER)X-(OER)M-D	
Efficiency pricing	NB=(OER)X-(OER)M-aD	NB=(SER)X-(SER)M-D
Impact of private consumption on public sector	NSB=NB' - C	
Social pricing	NSB=NB'-bC + rC	

Note : 1) NB = Net benefit
2) OER = Official exchange rate
3) SER = Shadow exchange rate
4) X = Exports
5) M = Imports
6) D = Domestic inputs
7) a = Accounting ratio
8) b = A rate of loss to the government due to not consumption of those resources
9) r = A rate of social gain due to its consumption
10) C = the impact on the public sector of the private consumption
11) NSB = Net social benefit
12) NB' = The net benefits of the project as valued by the numeraire

UNIDO and OECD provide an appraisal tool more in tune with the reality of developing world market characteristics. The critical difference between two methodologies is presented in Table 9.1, which shows that the UNIDO methodology chooses domestic consumption as its unit of measurement, while the OECD chooses foreign exchange.

3. Discount rates

For the evaluation of various resources, it is necessary to convert the future cash flow into the present value. The determination of an appropriate discount rate, however, is a difficult task, because the factors affecting the discount rate are varied and uncertain, depending on the characteristics which determines the business to be evaluated.[5] For instance, they vary according to social discount rate in public projects, the appropriate level of private investment in a public project in a mixed economic system, the role of the discount rate in the preservation of resources and environmental protection, and the level of the discount rate in the calculation of loss compensation resulting from the destruction of resources and environment. That is to say, even in a perfect capital market when the marginal investment profit in the private sector, the opportunity cost of the public sector, the consumer's interest rate, the producer's interest rate and the market interest rate are all the same, the level of the discount rate can be different due to different levels of uncertainty and risks. Therefore, the discount rate needs to be determined depending on which business was sacrificed or replaced by the business to be evaluated.

The discount rate used in the benefit-cost analysis of public project calls attention to two issues (Pyo and Chang, 1995). First, consistency is required in the application of a discount rate and cash inflows and outflows. In other words, when the cash inflow and outflow is a real

5) The choice of a discount rate is one of the most disputed subjects. It is noted that the choice of a time horizon and a discount rate can greatly influence the results of a benefit-cost analysis. See Howarth and Norgaard (1993), Maclean and Brown (1982), Markandya and Pearce (1991), Pearce and Turner (1990), among others. Lyon (1990) and Scheraga (1990) address conceptual and practical issues in choosing a discount rate. Much of the environmentalist literature argues against 'discounting'. The appropriate level of discount rate has a hot issue with sustainability, conservation and some form of inter-generational fairness. But it is not concluded that high discount rates cause environmental deterioration as is often supposed. Since low discount rates may tempt investment for natural resources even with low rate of returns, only zero or low discount rates are no unique way to accommodate environmental considerations. Therefore, the choice of discount rate is important, but the impact on natural resource and environment use is inconclusive because it depends upon relationship with other various factors (Pearce and Turner, 1990).

cash flow based on a constant price, the discount rate reflects a real rate of interest and an actual purchasing power. In the evaluation formula of benefit-cost analysis, the discount rate applied must be a real interest rate, as constant current value at the time of the analysis will be applied in each year. However, the interest rate that is observed in the market is a nominal rather than a real one. In principle, the nominal interest rate is deemed to be the sum of the real interest rate, risk premium of the goods and the expected inflation rate. In government securities, the market interest rate (return on investment of risk-free securities) is composed of a real interest rate and an expected inflation rate, excluding the risk premium, as in the following:

$$R = r + E\left(\frac{\Delta P}{P}\right) \quad (5)$$

R = risk-free rate of interest (nominal rate of interest)

r = real rate of interest or marginal productivity of capital

$E\left(\frac{\Delta P}{P}\right)$ = expected rate for inflation

Secondly, there are matters requiring special attention in the benefit-cost analysis, namely, the selection of the risk-free interest rate and how to determine the expected inflation rate. Risk-free securities are largely classified into bank deposits (fixed deposit, free saving, CD, etc.) and government bonds (monetary stabilisation security, local bond, corporate bond, mortgage, etc.). As for the expected inflation rate, an appropriate substitute variable must be devised for the expected inflation; since it cannot be observed in the market, “the adaptive expectations model” (Gibson, 1972) is frequently used, which specifies the expected inflation as a function of the past inflation.

Here the average annual rate of change of the general retail price index for the recent four years (1995 1998)[6] is applied to the expected rate of inflation in this analysis. In Table 2, the estimated real rate of interest is about 8%, which will be applied in this benefit-cost analysis.

<Table 2> The estimated real rate of interest

(Unit: %)

Year	Monetary stabilisation security (A)	3 year corporate bond (B)	Rate of inflation (C)	Estimated real rate of interest (D)	Estimated real rate of interest (E)
1995	11.65	13.8	4.5	8.22	7.28
1996	12.80	11.9	4.9	7.45	6.90
1997	14.83	13.4	4.5	9.62	8.67
1998	13.30	15.7	7.9	6.60	9.05
Average	13.15	13.7	5.45	7.97	7.98

Note : 1. D = (A+B)/2-C
2. E = (A+B)/2-average rate of inflation for four years (=(4.5+4.9+4.5+7.9)/4)

Source : Major economic indicators of Korea (Korea Statistic Administration, 1999)

4. Uncertainty and risk

Uncertainty can be defined as a situation regarding a variable in which neither its probability distribution nor actual value is known, while risk is a situation in which the probability distribution of a variable is known but its actual value is not.

Techniques for Uncertainty: sensitivity analysis

The objective of sensitivity analysis is to determine how sensitive a project's worth or earning capacity is to a change in a project variable. It largely consists of asking 'what if' questions. Steps in

6) The rate of inflation at year t_0 =1-(general retail price index at t_0 /general retail price index at t_{-1}).

sensitivity analysis include: (1) calculate the NPV of the base case; (2) decide the key factors likely to have an effect on the project's outcome; (3) determine the most likely changes in the value or quantity of each key variable; (4) re-work the analysis to determine the effects of the changes in variables on the costs and benefits streams and on the final measures of project worth; (5) interpret the results of the previous steps.

The analyst may have found it is useful to calculate the switching values of the various variables. These are simply the extent to which any one value can vary from its best estimates before the project becomes unacceptable, i.e. NPV=0. The sensitivity indicators (SI) are often presented as part of the sensitivity analysis results. The SI is a measure which indicates the sensitivity of the IRR to the rate of change in the variable.

$$SI = \frac{\%\ change\ in\ IRR}{\%\ change\ in\ the\ variable\ tested} \qquad (6)$$

There are a number of limitations of sensitivity analysis: (1) it cannot provide an indication of the sensitivity of the project to variation in more than one parameter at a time; (2) it is not a formal risk analysis because no account has been taken of the probability distribution of each variable; (3) there are no formal decision rules for the decision maker to follow.

Techniques for risk: simulation models

Risk can only be formally measured by considering the variability of probable outcomes. The ENPV (expected NPV) measures only the expected outcome given that there is limited knowledge about the probability distribution of NPV. Steps in risk analysis and simulation models are: (1) identify key variables; (2) identify the possible values of each key variable and corresponding probabilities; (3) find the range of possible NPV's by considering all combinations of each key variable; (4) set out the probability distribution of NPV's; and (5) calculate the measure of risk. Simulation models such as Monte Carlo method have the advantages that they can consider inter-dependencies between variables.

5. Economic analysis and financial analysis

Different decision-makers will want to evaluate projects from different points of view. Economic analysis takes the national viewpoint and addresses the question: what is the best option for the nation? A financial analysis examines which is the best option for the organisation contemplating the investment. The two questions are very different, and the results of the analyses can be very different. These crucial differences between economic and financial appraisal must be borne in mind throughout the analysis (Table 3).

<Table 3> The key differences between economic analysis and financial analysis

Item	Financial analysis	Economic analysis
1) Commodity price	Market price	Shadow price
2) Exchange rate	Official exchange rate	Shadow exchange rate
3) Fund	Market fund	Shadow fund
4) Purchasing cost for land	Actual land price	Opportunity cost of land
5) Discount rate	Opportunity cost of capital	Social opportunity cost
6) Tax	Include in costs	Exclude in costs
7) Subsidy	Including in benefits	Including in costs
8) Interest during construction	Including in costs	Excluding in costs
9) Payment cost of interest	Including in costs	Excluding in costs
10) Depreciation cost	Excluding in costs	Excluding in costs

6. Conventional BCA versus extended BCA

The most powerful criticism is the apparent unfairness in the way practical applications of the technique take into account the environmental impacts of economic developments. Bateman (1995) points out major issues on the traditional or conventional BCA: (1) conventional BCA often does not cover all items in the monetary terms. In particular, the environmental impacts of a project are often given non-money descriptive evaluations; (2) conventional BCA does lack a 'sustainability constraint' and a 'constant natural asset rule', i.e. it does not maintain the preservation of environmental services between generations (intergenerational equity).

Environmental and ecological economists attempt to integrate a sustainability criterion into extended BCA. Extended BCA for sustainability entails that Kaldor-Hicks potential compensation rule be extended in favour of an actual compensation rule for natural resources. Complete compensability and commensurability implies the inseparability between efficiency, equity and sustainability issues.

Ⅳ. Identification of benefits and costs

The basis for the establishment of wetland value is the "with and without" principle. If the value of the wetlands services is different from that of modified development or development at an alternative site, then the value of wetland development is the difference between the economic surpluses earned with developed wetlands and the economic surpluses earned without the wetlands development. This section provides the classification of benefits and costs for economic feasibility analysis with the project for wetland development into land use, mainly agricultural use (Table 4).

<Table 4> Classification of Benefits and Costs in Wetland Development

Benefits	Costs
1. Direct Benefits - Agricultural Production - Industrial Land - Water Use - Transportation Cost-savings 2. Indirect Benefits - Disturbance Regulation - Positive Atmosphere Regulation	1. Direct Costs - Construction Cost - Maintenance Cost 2. Indirect Costs - Commercial Fisheries Loss - Recreational Losses - Negative Wastewater Treatment - Negative Atmosphere Regulation

1. Wetland development costs

In Table 4 the economic costs incurred by wetland development consist of reclamation cost (construction costs, maintenance costs), commercial fisheries losses, recreational losses, water pollution costs, atmospheric pollution costs, and inestimable cost. These costs are described below.

Investment costs and maintenance costs

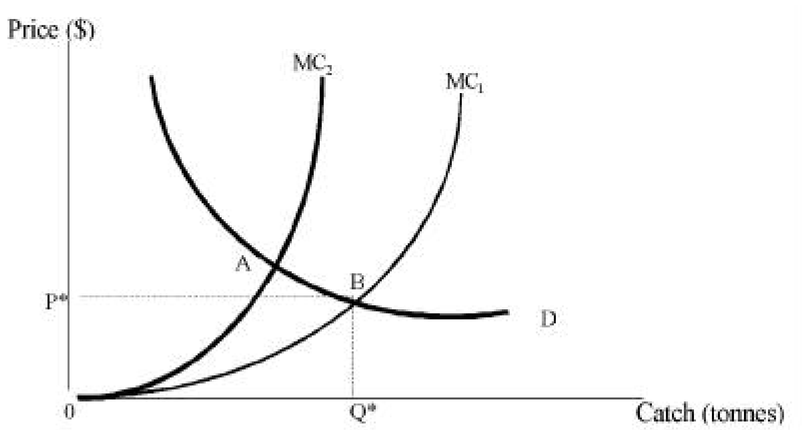
Major investment costs are construction costs including embankment, floodgates, roads, waterway, the facility of eliminating salt, pump station, reservoir and flume, construction of reclaimed rice paddy, design and inspection and management, and others (For detail, see Pyo, 2001). These costs are adjusted to calculate shadow price and economic costs excluding taxes and interest costs, and others.

Commercial Fisheries Loss

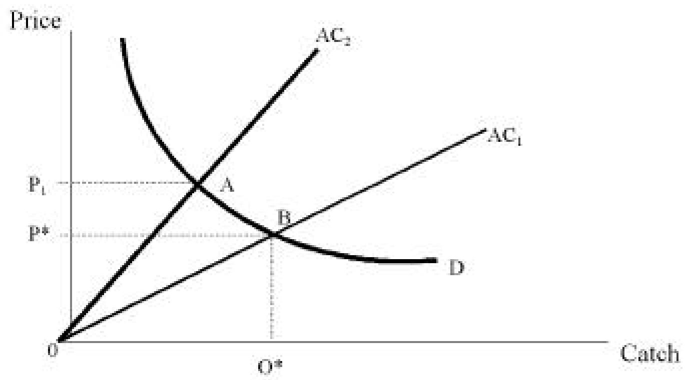
The basic question is how much higher fisheries profits would be or how much better off consumers of fisheries products would be if wetlands were kept in current condition? When wetlands are converted to alternative uses such as farmland and industrial use, commercial fisheries loss can be estimated by the value of consumer surplus plus economic rent. There are a number of studies to develop and determine the value of lost commercial fisheries in coastal wetlands: Lynne *et al.* (1981); Ellis and Fisher (1987); Farber and Costanza (1987); Bell (1989, 1997); Freeman (1991). The theoretical measure of the value of lost commercial fisheries is shown in Figure 4.

If the fishery is optimally managed (ignoring the intertemporal aspect of management), the market is in equilibrium with price equal to marginal cost (MC). A decrease in wetland acreage leads to a upward shift of the MC curve from MC_1 to MC_2. The economic loss of the decreased wetlands is sum of the change in producer's and consumer's surplus (the area of 0AB in Figure 4). If the fishery is an

<Figure 4> The welfare impact of a change in wetland area on an optimally managed fishery



<Figure 5> The welfare impact of a change in wetland area on open access fishery



open access, common property fishery, the condition of equilibrium is that price equal to average cost. The assumption of open access implies rent dissipation, total revenue equals total cost, and price equals average cost.

Here net economic rent, which is total revenue minus total cost, can be used as commercial fisheries loss under competitive market conditions. With historical average data, this study assumes that the rate of net income of fishing rights and fishing licences is forty percent of total product. In Korean coastal wetlands, many commercial fisheries activities are taking place in the form of various granted fishing rights or fishing licences[7] under the limited entry regime (For detail, see Pyo, 2001).

Water and air pollution costs

Rice paddies may have the intrinsic ability to reduce their own

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7) Under the fishing right various commercial resources including aquaculture, seaweed, various shellfishes, oyster, shrimp, and lugworm, etc. are produced, and under fishing license various species are caught. For detail, see Pyo and Chang (1995).

contaminants produced by fertilisers and pesticides, however, excess contaminants are released, and methane gas and nitrous oxide are also released. The estimated annual pollution costs calculated in Pyo(2001), are $227.64/ha and $45.29/ha for water and air pollution, respectively.

Other costs

Using contingent valuation method or travel cost method, recreational losses can be estimated. In this study, however, we assume that recreational losses by wetland development were roughly offset by the newly created recreational benefits from the new freshwater reservoirs.

2. Wetland development benefits

The economic benefits incurred by wetland development include (i) direct benefits from using agricultural and industrial land, and the uses of freshwater resource cost savings occurred by the improvement of inland transportation; (ii) indirect benefits from air pollution assimilation in rice field and rice plant, and storm protection and flood control (Table 4).

Effect of Agricultural Production

The main direct benefit in wetland development is a created economic surplus from agricultural production in the reclaimed farmland. In this analysis two scenarios are set up. Scenario 1 assumes that the effects of agricultural production occur after 10 years from the beginning of the project. This period reflect significant technical advances that reduce the periods of removing salt in reclaimed land to ten years from fifteen years. In Scenario 2 it is assumed that the effects of agricultural production normally appear after 15 years without considering the technical advances for removing the salt in the land. Dominant commodities comprise rice from the reclamation area and rye and vegetables for the hinterland.

Effect of Industrial Land

Developed wetlands may create land area for industries, which are planned as the scale of 5,240 ha in this project. Observations of land sales can be used to evaluate the net land value which subtracts build-up costs from the land price. The estimated net land value is assumed to be $302,500/ha, which are based on prices with the industrial area in this neighbourhood.

Cost-saving of transportation

Embankments, newly extended roads, and other arrangements developed by reclamation bring cost-savings of transportation including fuel costs and time value.

Uses of Freshwater/Disturbance/groundwater recharge

Two freshwater reservoirs whose size is 11,870 ha will be newly created, and they can store 570 million tons for mainly agricultural and industrial water. Of them the positive effects of about 400 million tons/year are already reflected in the effects of agricultural production as water for agricultural use. The remaining, about 200 million tons/year, are converted into the effects of water for industrial and residential use. In addition, freshwater reservoir and rice paddies have other functional values of groundwater recharge and storm protection especially by embankment. Storm protection values focus just on the economic cost savings to society attributable to the wetland moderation of flood and storm damages. As analysed in paper 8, these functional values of rice paddies and freshwater reservoirs are equivalent to that of a multi-purpose dam. As a substitute resource, the replacement cost of a multi-purpose dam is estimated at $0.35 per ton of water.

Effect of Atmosphere purification

Carbon fixing credits and oxygen discharge by rice paddies is often overestimated due to including their own effects produced for the farms themselves such as fertilisers and pesticides, and to double counting by adding each replacement cost for carbon fixing and oxygen discharge credits separately. In other words, since the afforestation as a substitute has dual effects such as carbon fixing and oxygen discharge credits, their replacement costs should not be added separately. This effect is cited from Pyo(2001).

Ⅴ. Results of conventional BCA

1. Analysis of NPV, IRR and B/C ratio

There are three discounting analysis techniques that this paper shall consider: net present value (NPV); internal rate of return (IRR); and benefit/cost ratio (B/C ratio). NPV takes net incremental cash flows and discounts them at the social rate of discount:

$$NPV = \sum_{t=1}^{t=n} \frac{NB_t}{(1+r)^t} - I_0 \qquad (7)$$

where NB_t is the net incremental cash flow in year t, considering the additional investments after the initial investment; r is the opportunity cost of capital, and I_0 is the initial investment. The decision criterion is that the project should be rejected if NPV<0, otherwise it should be accepted. On the other hand, the IRR is the rate of discount that lets NPV=0:

$$0 = - I_0 + \sum_{t=1}^{t=n} \frac{(1+D)^t}{NB_t} \quad \text{where } d = \text{project's IRR} \tag{8}$$

Projects are selected if the IRR is greater than the opportunity cost of capital (r), that is, $d>r$. Another way to calculate the economic decision criteria is B/C ratio by taking the present value of the benefit stream and dividing by the present worth of the cost stream:

$$\sum_{t=1}^{t=n} \frac{TB_t}{(1+r)^t} / \left(\frac{TC_t}{(1+r)^t + I_0} \right) \tag{9}$$

If the ratio is greater than 1 then the project should be undertaken.

Table 9 shows a summary of present value of benefits and costs at the discount rate of 8 % over 55 years from wetland conversion to agricultural and industrial land, and freshwater reservoir development, not considering the passive-use values. As noted earlier, Scenario 1 assumes that the effects of agricultural production occur after 10 years from the beginning of the project. This period reflects significant technical advances that reduce the periods of removing salt in reclaimed land to ten years from fifteen years. Scenario 2 assumes that the effects of agricultural production normally appear after 15 years without considering the technical advances for removing the salt in the land.

Benefits come from agricultural production, industrial land, air quality improvement, water use, and cost-savings of transportation. The major portion of total development benefits is benefit of agricultural production, which is 54% for Scenario 1 and 44% for

Scenario 2. Next one is industrial use, which poses 26% for Scenario 1 and 31% for Scenario 2. Considering the size of them (agricultural land: 16,450 ha; industrial land: 5,240 ha) we can find the benefit of industrial use is much relatively higher than that of agricultural use. In addition, the benefits of water use including disturbance/ groundwater recharge/flood control pose the third place, which portion of total benefits is 20%and 25% each Scenario respectively. Of total costs the weight of lost fisheries including fishing rights, fishing licences and others account for the largest share, about 60%. Investment costs are 37% of total costs. Surprisingly, accounting for functional costs such as water and air pollution costs is quite relatively small, whose portion is only 1% of total costs.

Wetland development is preferred to wetland preservation in economic terms under Scenario 1 since the results indicate a positive NPV (49,029.96 thousand dollars) and an IRR of 8.28 which is greater than opportunity cost of 8%. Under Scenario 2, however, wetland development project appears to be rejected for economic feasibility with the discount rate of 8%, yielding NPV=-271,575 thousand dollars and IRR of 6.50 %. Note that the economic feasibility analysis using BCA in this project is quite sensitive to technical change of removing salt in the reclaimed area. In other words, technical advances, especially related to reclamation technology, can increase pressures on wetland development.

As shown in Figure 6, the present values of these streams decrease in line with the increasing discount rate. An increase in discount rates will offer a motive for wetland preservation more than wetland development.

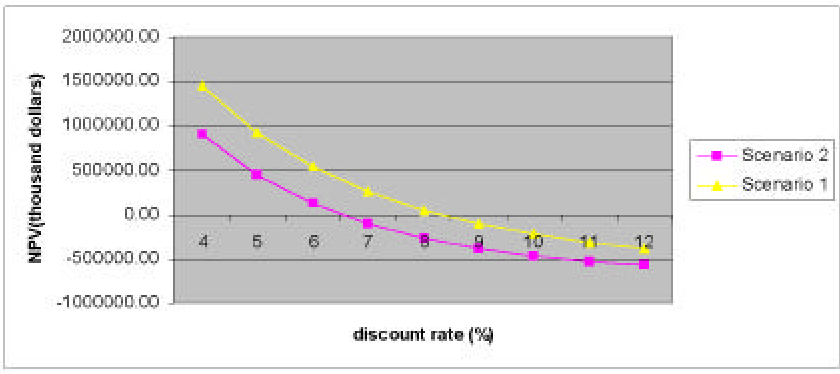
<Table 9> A summary of PV over 55 years from wetland development using conventional BCA

(Unit: thousand dollars)

Items		Scenario 1	Scenario 2
Benefits	Agricultural production	960,513	642,553
	Air quality improvement	7,997	5,353
	Industrial use	462,676	462,676
	Water Use	362,575	362,575
	Inland Transport	169	169
Total Benefits		1,793,931	1,473,326
Costs	Construction	637,874	637,874
	Maintenance	54,513	54,513
	Fishing Right	864,385	864,385
	Fishing License	47,501	47,501
	Common fisheries	75,975	75,975
	Others Fisheries	47,785	47,785
	Water and air pollution	16,875	16,875
Total Costs		1,744,901	1,744,901
NPV(discount rate=8 %)		49,030	-271,575
IRR(%)		8.28	6.50
B/C ratio		1.03	0.84

Source: See Appendix D in Pyo(2001) for detail

<Figure 6> NPV curves in conventional BCA



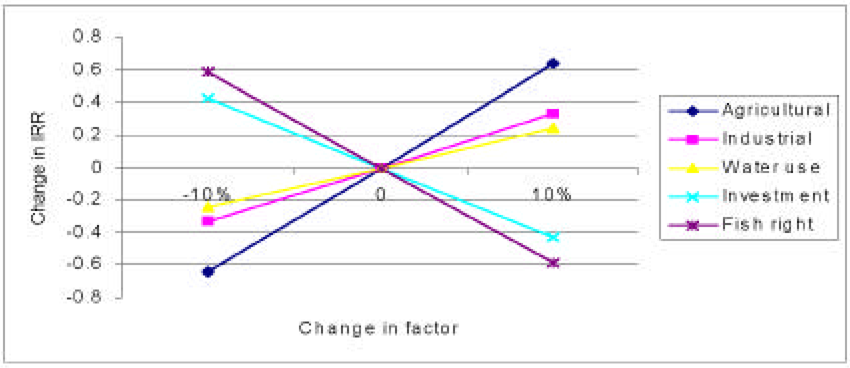
2. Sensitivity analysis

The economic performance given in Table 9 and Figure 6 needs to be critically examined in order to test their sensitivity to changes in important assumptions. Table 10 or Figure 7 and Figure 8 illustrate the sensitivity of the project's IRR to changes in various factors including positive factors (agricultural production, industrial use, and water use) and negative factors (investment and lost fishing rights costs). Not surprisingly, the rate of change in agricultural production is most sensitive to IRR in the case of Scenario 1, while the rate of change in lost fishing rights cost carries most weights in determining the value of IRR in case of Scenario 2.

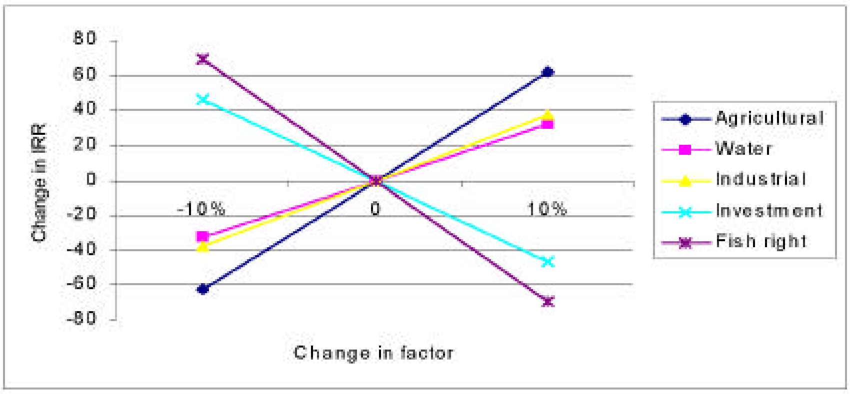
<Table 10> Sensitivity analysis using sensitivity indicators (SI)

Factor	Scenario 1		Scenario 2	
	SI	Sensitivity rank	SI	Sensitivity rank
Agricultural Production	0.64	1	0.62	2
Industrial use	0.33	4	0.38	4
Water use	0.24	5	0.32	5
Investment cost	0.43	3	0.46	3
Lost fishing right	0.59	2	0.69	1

<Figure 7> Sensitivity analysis using SI in Scenario 1



<Figure 8> Sensitivity analysis using SI in Scenario 2



Ⅵ. Results of extended BCA

Kopp (1992) argues that passive-use values may be incorporated into BCA on the basis of Samuelsonian neoclassical welfare economics.8) Over the years, research into BCA has sought to expand the types of benefits that can be measured in monetary terms. As environmental awareness and the perception of environmental threats have increased, much of this research has focused on resource allocation decisions involving natural resources and environmental systems. It should be noted in particular that much of the coastal wetlands of Korea has a value of amenity, aesthetic, recreational, ecological or archaeological value which can be measured as major potential costs and benefits in the project. Hence there are risks in

8) Some economists tend to doubt the significance of values that are derived in the absence of observed behaviour. Such issue of existence or passive-use value was debated by Rosenthal and Nelson (1992), arguing that existence values should not be included in BCA, and by Kopp (1992), arguing that they should be included. Another remarkably critical debate on CV method for estimating passive-use values is included in Hausman (1993).

using a conventional BCA based on narrowly defined economic appraisal methods to evaluate coastal wetland preservation or development (Parker and Thompson, 1988). An “extended” BCA takes into account the identification and quantification of all impacts including passive-use values.[9]

A strong motivation for wetland development exists since net benefits from wetland development sometimes exceed those from preservation in a conventional economic appraisal, which excludes passive-use values. In the conventional case, when the benefits of resource preservation to users exceed the cost, consideration of passive-use benefits is superfluous as long as they are not negative. That is, passive-use values can play a relatively crucial role when this inequality is reversed (McConnell, 1997). An extended economic appraisal considering the value of environmental resources including preservation value, therefore, provides more useful means to decide whether wetlands will be preserved in its natural state or be developed.

In contrast with conventional BCA of Table 9, Table 11 describes the result of extended BCA adding the passive-use values to conventional BCA under the condition of the same scenarios. The results show that none of the cases can be accepted to undertake the project for wetland development. For instance, the extended BCA reflecting passive-use values for the first five years diminishes IRR in proportion to about 34.5 % compared to that of conventional BCA, which implies BCA can heavily be affected by passive-use values. The results of extended BCA shows that coastal wetland preservation is preferred to its development in economic terms even though these

9) As noted earlier, Bateman (1995) attempts to justify the extended BCA by incorporating the constant natural asset rule for a sustainability criterion into it.

cases assumed to calculate passive-use values only for one-year payment under a conservative approach.[10)]

<Table 11> Estimates of IRR and B/C ratio in extended BCA

Payment Periods of Passive-use Values	Scenario 1		Scenario 2	
	IRR (%)	B/C ratio	IRR (%)	B/C ratio
1 year	7.42	0.85	5.85	0.77
5 years	5.42	0.68	4.25	0.60
10 years	4.06	0.57	3.09	0.50

Note : The aggregated annual passive-use values estimated in the previous section (175.7 million dollars in the Scenario of low estimate),[11)] were reflected by payment period.

10) Evidence is also lacking over the behaviour of passive-use values for environmental assets over time (temporal stability). Currently it would seem that such values are relatively stable over periods of a few years but longer-term evidence is not available (Stevens *et al.*, 1994).

11) The validity test of decomposition method for total economic value in section 5.4.5 illustrated that the hypothesis - passive-users hold only the passive-use value - should be rejected. In other words, Group A (who are asked to decompose their total value into six components which include three components for use and passive-use values, respectively) allocated total value to about 51% for the use values and about 49% for the passive-use values, while Group B (who are asked to decompose it into four components which include one component for the use value and three components for the passive-use values) decomposed total value into 28% for the use value and 72% for the passive-use values. That is, even passive-users keep use values as well as passive-use values. Since this result includes large use values, this raises the question as to whether or not such total value should be incorporated in passive use value of the BCA. Therefore, the figure of 175.7 million dollars was calibrated by the portion of the passive-use value to total value (50%) and the response rate of the positive WTP (57.9%) for a conservative analysis. In other words, it reflects only 50% of total value according to NOAA (Federal Register, 1994)'s recommendation and positive response rate (57.9%) of WTP. That is, this figure (175.7 million dollars) represents about 29% (= 0.5 * 0.579) of the total value estimated in Paper 6 so as to avoid the double counting problem.

Ⅶ. Goal-seeking model for passive-use values

This part is to speculate about the impact on BCA of passive-use values by using a goal-seeking model.[12] In project appraisal it is the standard way of dealing with situations where the magnitude of one of the variables (in this case passive-use values) is unknown. Accordingly, what the analysis tries to do is to calculate the point of what the economic worth of the project switches from positive to negative (i.e. identifying the switching value). In order to seek the minimum level[13] of passive-use values rejecting the project of wetland development at the given rate of social discount and other benefit and cost factors, Table 8.11 shows various levels of passive-use values at the national and household level[14]

For example in Table 12, given the assumption of Scenario 1 with the social discount rate of 5% which is quite low and can be easily accepted in Korea, an aggregate gross WTP for passive-use values should be as high as or more than $929.04 million at one time in order to reject the development project. Otherwise it should be annually allocated $214.58 million for 5 years, $120.31 million for 10 years. In other words, from a perspective of each household, annual tax payment is $123.83, $28.60, and $16.04 for each payment period.

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12) Goal seeking method is to seek a desired level of performance by adjusting a special variable, and it can be estimated by software such as EXCEL.

13) The minimum level is the level to reach NPV=0, and an annuity, which individual is willing to pay for wetland preservation for n years, can be calculated by the following equation (Brigham, 1980):

$$Annuity = minimum\ level / ((1-(1+k)^{-n})/k).$$

14) The total amount of passive-use values at the national level represents the minimum level of aggregated estimates for the nation as a whole to reject the project, and passive-use values at the household level is annual payment per household for preservation. As noted in the previous section, 7,502,786 households (57.9% of total household) of Korea are assumed to state a positive WTP amount for preservation.

Given that we have only an approximate notion of what the magnitude of passive-use values is, in this or any other situation, it would be unwise to exclude them from any benefit-cost analysis of projects of this kind since other studies have indicated that passive-use values for wetlands are likely to be positive and non-trivial. Moreover, the root of the controversy about wetland conversion should disappear because irreversible loss would result in irrecoverable damage to society. Taking into account average passive-use value as is reviewed in empirical studies of Pyo (2001), annual payment level for passive-use value ranging from $4.93 to

<Table 12> Estimating the magnitude of passive-use values for wetland preservation

		Discount rate	Payment period		
			1year	5 years	10 years1
Passive-use values	National level (million dollar)	5%	929.04	214.58	120.31
		6%	543.39	129.00	73.83
		7%	259.56	63.30	36.96
	Household level (dollar)	5%	123.83	28.60	16.04
		6%	72.43	17.19	9.84
		7%	34.60	8.44	4.93

Note : 1. Bequest values (intergenerational altruism) may suffer from the same type of double counting as proposed by Madariaga and McConnell (1987). Thus, only the values of the present generation (for about 10 years) should be considered for BCA. The survey design should specify a payment period over which the status quo will be completely paid for. The discounted present value over this period for this payment constitutes the entire benefit stream (Lazo *et al.*, 1997).
2. For example, the figure of $123.83 represents a single payment for passive-use values at the household level, while the figure of $16.04 represents an annual payment of that amount for 10 years (i.e. an annuity) at the discount rate of 5% which each household should pay so that the wetland development project can be rejected.

$16.04 for 10 years seems not to be relatively high or unrealistic.[15)]

As Freeman (1993) has pointed out, there is a growing consensus among most economists that people may place positive values on important natural assets they never plan to use, and they would probably not rule out the theoretical possibility of passive-use values for major natural assets. Therefore, passive-use values should be treated as equivalent to use values in assessing preservation or development work with BCA.

Ⅷ. A comparative analysis of wetland preservation values and development values to agricultural use

In fact, the total values of wetlands and rice paddies created by wetlands share with those of other resources. Therefore, the complicated problems of allocation for worth are accompanied. BCA can use an overall assessment and financial decision the criteria for a proposed project without the problem of worth allocation. A direct comparison of wetland value and rice paddy value should be very sensitive according to criteria and methods of worth allocation, but make intuitive assessment and direction easily. Table 13 illustrates the total value of wetlands is about three times higher than that of rice paddies developed by reclamation.

15) Bishop and Welsh (1992) argued the issue associated with adding up existence values in the project selection. Adding up the existence values of each of them for any given member of society, the sum would become implausibly large. For an example, if the striped shiner is worth $4 to the average Wisconsin taxpayer and there are 100 obscure endangered species in Wisconsin, then would it follow that there is a value of $400 per taxpayer for all obscure endangered species? They argued that this does not make existence values wrong or irrelevant, but it does make them more difficult to interpret for policy.

<Table 13> A comparison of the wetland preservation values and development values to agriculture

(Unit: thousand dollars/ha)

Item	NPV	Size (ha)	Unit value	
			Wetland	Rice paddy
Fishery rights	864,384.83	21,690[1]	39.85	
Fishing licences	47,500.58	49,970[2]	0.95	
Other fisheries	92,309.48	21,690	4.26	
Waste treatment[6]			10.49	
Intrinsic value[7]	75,745.3	21,690	8.10	
Agricultural production	642,553[5]	28,320[3]		22.69
Water use[8]	362,575.49	28,320		12.80
Air quality	5,353	28,320		0.19
Water & Air pollution	16,874.76	28,320		-0.60
Reclamation cost	692,387.58	50,910[4]		-13.60
Total value			63.65	21.48

Note : 1. Reclaimed wetland areas
2. Reclaimed wetland area +remaining wetland area
3. Rice paddy and freshwater reservoir areas developed by wetlands (=16,450 ha + 11,870 ha)
4. Total development areas (Rice paddy, freshwater reservoir, hinterland, and industrial areas developed by wetlands) = 16,450+11,870+17,350+ 5,240
5. It includes additional values of hinterland improved by wetland development.
6. It is restricted to economic marginal values, not total ecological values.
7. It is reflected by one-year period payment.
8. Water use effect includes groundwater recharge, flood control, and water supply for industrial and residential excluding agricultural use.

IX. Conclusion

BCA can play an important role in legislative and public policy debates on protecting and developing natural resources and environment with other methods such as cost-effectiveness analysis, multi-attribute criteria analysis, environmental impact on assessment analysis, and so on. In particular BCA can be of great help to evaluate a public policy for decision-making and to shape its progress if properly done, even though it is sensitive to identify the factors to be evaluated, and to change them with risk and uncertainty.

This paper addressed a framework for wetland economics related to the issues of preservation and development with intertemporal and irreversible consideration, and reviewed the various theoretical issues on BCA. It next identified the specific benefits and costs, and the results of various approaches using BCA were estimated. In conventional BCA excluding passive-use values, two scenarios were employed: in Scenario 1 it is assumed that the effects of agricultural production and its air quality improvements occur after 10 years from the beginning of the project. With this optimistic estimate this period is 5 years shorter than the status quo due to the expected technical advances for removing the salt from reclaimed land. Scenario 2 is assumed that the period is normally 15 years without considering the technical changes. The results showed wetland development is preferred to its preservation in Scenario 1, yielding NPV of $49,030 thousand at the discount rate of 8 %, and IRR of 8.28 %, B/C ratio of 1.03. In contrast to Scenario 1, Scenario 2 rejects economic feasibility for the development project at the discount rate of 8%, yielding a negative NPV of $271,575 thousand, IRR of 6.5 % and B/C ratio of 0.84. In sensitivity analysis using SI, a change of agricultural production factor is most sensitive to a change of IRR under Scenario 1, while under Scenario 2 lost fishing rights cost factor is most sensitive. With an argument of extended BCA including passive-use values, the estimates of IRR are 7.42 %, 5.42 %, and 4.06 % for 1 year- payment, 5 year-payment, and 10 year-payment of passive-use values, respectively under Scenario 1. Under Scenario 2 the estimates of IRR are 5.85 %, 4.25 %, and 3.09 %, respectively. They show that consideration of passive-use in BCA can play a crucial role in reversing the results suffered by weak persuasion for wetland preservation. Further analysis using a goal-seeking model produced the specific minimum magnitudes of passive-use values so as to preserve wetlands in this project according to national level and household level with some different possible discount rates (5%, 6%, and 7%). If about fifty-eight percent of all households in Korea can have their annual WTP of $5 to $16 for preserving wetlands only for 10 years, wetlands would progressively be protected even under the worst scenarios of low discount rates. Finally, this paper provided a direct and intuitive comparison of total wetland preservation value and total development values for agricultural use. Surprisingly the results illustrated that total value of wetland preservation is about three times much higher than that of development for agricultural use, even though this method is quite sensitive to criteria and methods of resource allocation. It is noteworthy that only agricultural use will be less efficient than wetland preservation if the project does not include industrial use of reclaimed lands. Without industrial use of reclaimed lands in this project, IRRs abruptly decline 5.68% and 4.15% under Scenario 1 and Scenario 2 even in conventional BCA *ceteris paribus*.

To this end, these various empirical studies imply major and necessary extensions to conventional BCA are inevitable and the integrated environmental assessment of economic and ecology including sustainability and equity issues should be taken into account.

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